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Commingled Uranium Tailings Study

Volume II
Technical Report

June 30, 1982

Prepared for:
U.S. Department of Energy
Assistant Secretary for Defense Programs
Office of Defense Waste and Byproducts Management

Under Contract No. DE-AC07-76GJO1664

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Prepared by:
U.S. Department of Energy
Grand Junction Area Office
Grand Junction, Colorado
and
Bendix Field Engineering Corporation
Grand Junction Operations
Grand Junction, Colorado
Under Contract No. DE-AC07-76GJO1664

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U.S. Department of Energy
Assistant Secretary for Defense Programs
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Washington, D.C. 20545

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Section I

SUMMARY

Public Law 96-540, Section 213, directs the Secretary of Energy to develop a plan for a cooperative program to provide assistance in the stabilization and management of defense-related uranium mill tailings commingled with other tailings. In developing the plan, the Secretary is further directed to: (1) establish the amount and condition of tailings generated under Federal contracts; (2) examine appropriate methodologies for establishing the extent of Federal assistance; and (3) consult with the owners and operators of each site.

This technical report summarizes U.S. Department of Energy (DOE) and contractor activities in pursuit of items (1), (2), and (3) above. Recommendations regarding policy and a cooperative plan for Federal assistance are under separate cover as Volume I.

AMOUNT AND CONDITION OF TAILINGS

Both the Atomic Energy Commission (AEC) and the producing mills maintained records of the tons of ore fed to process (equivalent to tons of tailings generated) for the AEC contract period. Discussions with mill owners have led to perfect reconciliation of the figures for 9 of the 13 sites. The variance in Government and mill operator records of the amount of tailings at the other 4 sites averaged less than 2 percent, with 3.9 percent as the high. The records are summarized in Table 1. The Government figures have been used in this report in most cases. In some instances, these figures are slightly different than those reported to Congress in 1979, as minor errors were discovered in the earlier summations.

The defense-related tailings exist under a variety of conditions, depending upon site-specific factors. While these tailings generally lie beneath the commercial-related tailings produced in later years, they may also have been isolated from commercial production. Most of the defense-related tailings are physically commingled with other tailings in currently active piles. About 30 percent of the tailings are in inactive AEC-only or inactive commingled piles. Table 2 summarizes the quantities of tailings relevant to each site as of year-end 1981.

ALTERNATE METHODOLOGIES FOR FEDERAL COST-SHARING AND THEIR RESPECTIVE COSTS

Order-of-magnitude cost estimates for stabilizing the commingled (and/or AEC-only) tailings at each site as of January 1982 are summarized in Table 3. The third column reflects the significant reduction in costs to comply with the State of New Mexico's regulations as compared with the costs of compliance with the more stringent Nuclear Regulatory Commission (NRC) regulations. These cost estimates are highly subjective, though inputs from mill owners, consultants, and model studies were considered. If an average of $4.80 per ton of tailings is spent for stabilization, the same average as for six of the sites designated under the Uranium Mill Tailings Remedial Action Program

Table 1. Comparison of Records: Ore Fed to Process (Tons)

Mill	DOE Records		Company Records		Percent Difference	
	Ore Fed Under AEC Contract	Total Fed to Process During Contract Period	Ore Fed Under AEC Contract	Total Fed to Process During Contract Period	Ore Fed Under AEC Contract	Total Fed to Process During Contract Period
Cotter, Colo.	315,000	319,400	317,836	319,415	0.9	<0.1
UCC, Colo.	5,701,186	5,878,778	5,701,186	5,878,778	0	0
Anaconda, N. Mex.	8,836,679	10,032,560	8,962,624	10,062,624	1.4	0.3
Homestake, N. Mex.	11,411,223	12,531,127	10,982,796	12,334,300	3.9	1.6
Kerr-McGee, N. Mex.	10,031,748[a]	11,350,699[a]	10,031,748[a]	11,350,699[a]	0	0
TVA, S. Dak.	1,624,629	1,643,148	1,624,629	1,643,148	0	0
Atlas, Utah	5,946,420	6,394,000	5,946,420	6,394,000	0	0
Dawn, Wash.	1,171,313	1,171,313	1,171,313	1,171,313	0	0
FAP, Wyo.	2,081,100	2,676,313	2,095,524	2,676,313	0.7	0
Pathfinder, Wyo.	2,673,514	3,489,317	2,674,000[b]	3,489,317	0	0
Petrotomics, Wyo.	724,987	786,928	724,987	786,928	0	0
UCC, Wyo.	2,103,363	2,463,809	2,103,363	2,463,809	0	0
WNI, Wyo.	3,346,636	3,544,542	3,346,636	3,544,542	0	0
Totals	55,967,798	62,281,934	55,683,062	62,115,186	<0.5	<0.3

[a]Mine backfill subtracted.

[b]Rounded; excludes 168,000 tons of heap-leach ore.

Table 2. Summary of Tailings Quantities: Commingled Tailings Study (Millions of Tons)

Mill	Total Through 1981	AEC-Related (Base Case)	Commercial (Base Case)	Commingled Piles	AEC-Only Piles	Commercial Only Piles
Cotter, Colo.	1.9	0.3	1.6	1.5	0	0.4
UCC, Colo.	9.9	5.7	4.2	9.4	0.5	0
Anaconda, N. Mex.	23.6	8.8	14.8	22.8	0.8	0
Homestake, N. Mex.	21.2	11.4	9.8	19.9	1.3	0
Kerr-McGee, N. Mex.	30.4	10.0	20.4	30.4	0	0
TVA, S. Dak.	2.0	1.6	0.4	1.5	0.5	0
Atlas, Utah	10.2	6.0	4.2	10.2	0	0
Dawn, Wash.	3.0	1.2	1.8	0	1.2	1.8
FAP, Wyo.	5.9	2.1	3.8	5.4	0.5	0
Pathfinder, Wyo.	9.5	2.7	6.8	8.2	0	1.3
Petrotomics, Wyo.	5.5	0.7	4.8	5.5	0	0
UCC, Wyo.	7.3	2.1	5.2	6.5	0	0.8
WNI, Wyo.	7.7	3.4	4.3	7.7	0	0
Totals	138.1	56.0	82.1	129.0	4.8	4.3

(UMTRAP) studied by Ford, Bacon & Davis Utah, Inc., in 1981, total costs for stabilizing the tailings would be $640 million. This total cost estimate compares favorably with the sum of the site-specific estimates of $590 million.

Table 3. Summary of Estimated Costs: Commingled Tailings Study (millions of dollars)

Mill	Total Cost of Reclamation of Commingled Tailings Under: (a) NRC Regulations	(b) Modified Regulations
Cotter, Colo.	15	10
UCC, Colo.	40	10
Anaconda, N. Mex.	100	60
Homestake, N. Mex.	90	60
Kerr-McGee, N. Mex.	120	40
TVA, S. Dak.	20	10
Atlas, Utah	40	5
Dawn, Wash.	15	5
FAP, Wyo.	30	20
Pathfinder, Wyo.	35	10
Petrotomics, Wyo.	25	10
UCC, Wyo.	30	10
WNI, Wyo.	30	10
Totals	590	260

(a) Costs are based on NRC regulations and include moving tailings in some cases. The cost estimates were subjectively derived by a committee of DOE and contractor personnel after consideration of inputs from mill operators, consultants, and mill modeling studies. The estimates are intended only to provide order-of-magnitude insight into the costs; individual estimates may be in error by as much as ± 50 percent. Costs for stabilizing tailings in "commercial-only" piles are not included.

(b) Costs reflect compliance with regulations comparable to the State of New Mexico's Environmental Improvement Division tailings regulations. As in column (a), costs were subjectively derived and are intended to be order-of-magnitude estimates.

Four general cost-sharing approaches have been considered:

1. Share cost on the ratio of tonnage of AEC-related tailings to total tonnage of tailings produced or to be produced up to the time of final stabilization.

2. Share cost on the ratio of acreage (area) disturbed by or covered with tailings (and requiring reclamation) under AEC contracts to the total acreage covered by tailings at decommissioning.

3. Assume that the mills were shut down at the end of the AEC purchase program (or some earlier date) and, through the use of engineering assessments, project stabilization costs for the quantity of tailings existing at that time. The Government might then fund this "base" amount, with the companies being responsible for the incremental costs.

4. Negotiate, or unilaterally establish, a flat fixed Government contribution based on dollars per ton of defense-related tailings, pounds of U_3O_8 in concentrate purchased by the Federal Government, or dollars per acre disturbed by the defense-related tailings.

Table 4 summarizes projected Government contributions for cost-sharing approaches involving tonnage and area ratios. The ratios used in the table have been calculated as of year-end 1981 and will decline at those mills where commercial tailings continue to be commingled with AEC-related tailings. However, the total stabilization costs are likely to increase as the size of the piles grows, so the net Government contribution (the product of a declining ratio and an increasing total cost) may be larger or smaller than the totals shown. The figures are based on the assumption that current NRC regulations will be enforced and the costs would be as shown in Table 3. If less stringent standards are adopted, the Government contributions may be less than half of the totals shown.

The use of several tonnage ratios, possibly reflecting calculation at different times during the mill life, and appropriately including or excluding tailings removed for backfill or tailings impounded in commercial-only areas, may result in a more equitable approach than applying a single overall ratio to all costs. While the multiple tonnage ratio approach would currently result in a Government contribution identical to the single ratio approach, as shown in Table 4, it will not be identical in the future after substantial quantities of tailings are impounded in commercial-only areas.

Table 5 summarizes the expected Government contribution for the other cost-sharing approaches considered: engineering assessment and flat "fixed-fee" payments. Neither tonnage nor area ratios are relevant for either approach; even the issue of stabilization standards and regulations may be irrelevant if a fixed payment approach is adopted.

Table 4. Summary of Estimated Costs: Commingled Tailings Study
(millions of dollars)

Mill	Government Contribution for Tonnage and Area Cost-Sharing Approaches (Under NRC Regulations)		
	(1) Basic Tonnage Ratio	(2) Basic Acreage Ratio	(3) Multiple Tonnage Ratio (reference case)
Cotter, Colo.	5	5	5
UCC, Colo.	25	40	25
Anaconda, N. Mex.	40	100	40
Homestake, N. Mex.	50	80	50
Kerr-McGee, N. Mex.	40	105	40
TVA, S. Dak.	15	15	15
Atlas, Utah	25	35	25
Dawn, Wash.	10	15	10
FAP, Wyo.	10	30	10
Pathfinder, Wyo.	10	40	10
Petrotomics, Wyo.	5	25	5
UCC, Wyo.	10	30	10
WNI, Wyo.	15	15	15
Totals	260	535	260

(1) Cost figures are "base case" tonnages for AEC-related tailings divided by total tailings in commingled piles as of 1/1/82, times total costs for NRC regulations, column (a), Table 3. Costs have been rounded to the nearest $5 million. Adjusting AEC-related tailings for "bonus" pounds delivered in 1969 and 1970, or for coproduct vanadium, would result in slightly lower figures for the Government contribution (see Section V).

(2) Cost figures reflect the acreage of solid tailings impoundments attributable to AEC tailings as of 1/1/70, divided by the acreage of solid tailings impoundments as of 1/1/82, excluding areas of "commercial-only" tailings, times column (a), Table 3. Costs have been rounded to the nearest $5 million. Acreages for solution ponds have not been included in calculating the area percentage.

(3) A reference case using two tonnage ratios has been compiled. The approach applies different ratios to specified cost items (see Tables 20 and 21 in Section VIII). Costs shown utilize ratios calculated as of 1/1/82, and have been rounded to the nearest $5 million.

Table 5. Summary of Estimated Costs: Commingled Tailings Study (millions of dollars)

Mill	Engineering Assessment[b]	Government Contribution for Other Cost-Sharing Approaches[a]		
		Flat Fee, \$5.00/Ton Tailings	Flat Fee, \$1.00/Lb. U_3O_8	Flat Fee, \$150,000/Acre Disturbed
Cotter, Colo.	5	2	3	11
UCC, Colo.	30	28	24	13
Anaconda, N. Mex.	60	44	40	51
Homestake, N. Mex.	40	57	43	28
Kerr-McGee, N. Mex.	60	50	43	43
TVA, S. Dak.	20	8	6	19
Atlas, Utah	35	30	38	18
Dawn, Wash.	5	6	5	9
FAP, Wyo.	20	11	7	18
Pathfinder, Wyo.	10	13	17	15
Petrotomics, Wyo.	5	3	3	21
UCC, Wyo.	10	11	6	9
WNI, Wyo.	10	17	15	25
Totals	310	280	250	280

[a]Modeling studies have suggested that allowances of \$5.00 per ton of tailings, \$1.00 per pound U_3O_8, or \$150,000 per acre disturbed are reasonable for tailings stabilization under NRC regulations. If these values were used as a basis for flat fees, the total Government assistance would be in the \$250 to \$280 million range.

[b]Engineering-assessment cost figures are subjectively derived, low-precision estimates of the costs to meet NRC regulations, assuming the mills ceased production at the end of their AEC contracts. Cost estimates were rounded to the nearest \$5 million. The essence of this approach would be to refine these cost estimates.

If a simplistic cost-sharing approach is chosen, the Government contribution could range from \$250 to \$535 million, assuming current NRC regulations are enforced. An earlier GAO report, updated for inflation, estimated the Government's cost of "cleaning up" defense-related tailings at \$3 to \$175 million for 12 of the 13 sites. Most of the cost estimates based on model studies indicate costs in the range of \$200 to \$400 million. If the NRC regulations are modified to become more like those adopted in New Mexico, an Agreement State, the Government contribution could be in the \$100 to \$175 million range.

None of the simplistic cost-sharing approaches appear to be equitable to all mill operators and the Federal Government. Recognition of site-specific cost factors and the use of multiple tonnage ratios may be needed to achieve a fair and impartial sharing of the costs.

MILL OWNER VIEWS

Meetings held with mill owners privately and in joint session have revealed that there is no consensus of opinion among them as to:

1. Which method of cost-sharing should be adopted.
2. What costs should be included in a cost-sharing formula.
3. The mechanism as to how the operators should receive the Government contribution.
4. Who should administer the program.

However, the majority of the operators favor:

1. Establishing a list of cost factors to be shared at each specific site.
2. Negotiating to share each cost item on the basis of percentages of tons of tailings, pounds concentrate produced, acres disturbed, or some combination.
3. Reimbursing the operator as costs are incurred, including past and future interim stabilization expenses.

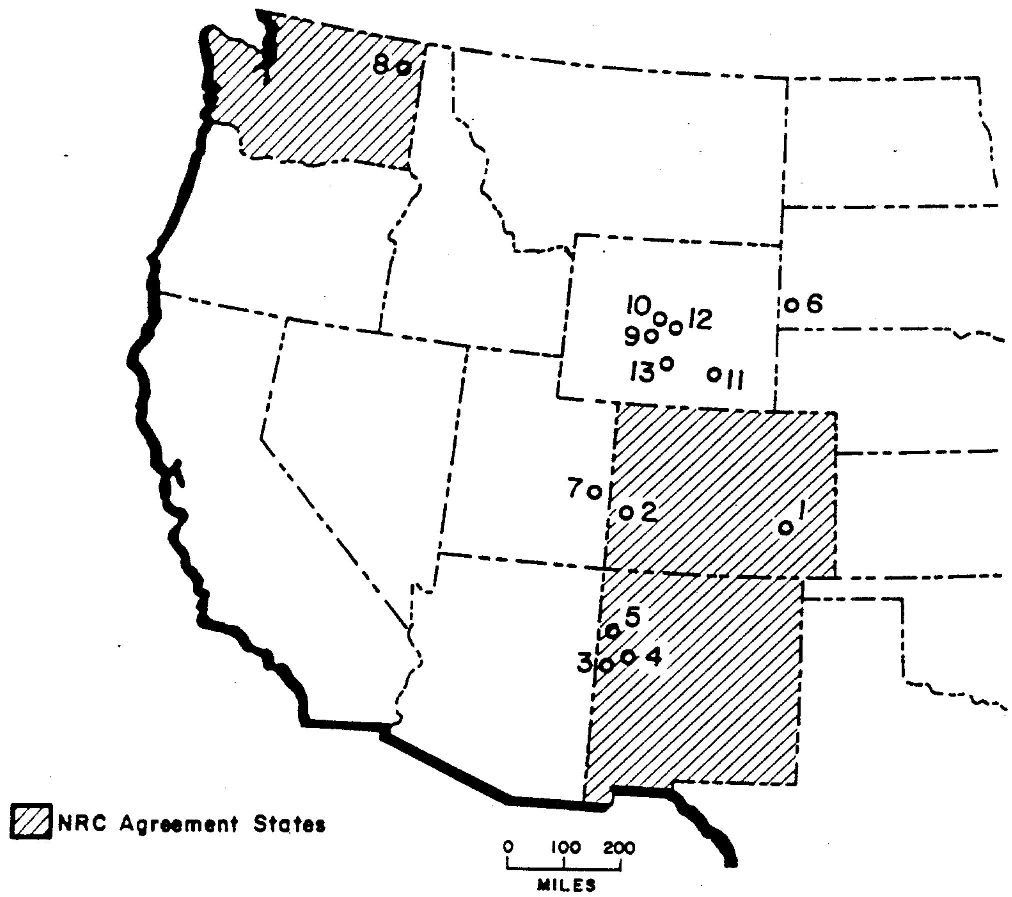
Section II

BACKGROUND

Federal contracts for purchasing uranium concentrate to support defense programs were made by the U.S. Army's Manhattan Engineer District (MED) from 1942 to 1946 and by the AEC from 1947 through 1970. Four mills recovered uranium for the Army mostly from the reprocessing of old radium and vanadium mill tailings. A total of 34 commercially operated mills produced uranium concentrate for sale to the Atomic Energy Commission. Of these, 13 are still under current NRC or state license and have defense-related tailings commingled with other tailings. The locations of the 13 sites are shown in Figure 1. A brief history of the Federal Government's domestic uranium procurement program is presented in Appendix D, and a chronology of the program is presented in Figure 2.

The uranium procurement contracts were quite simply contracts for the purchase of (an agreed-upon quantity of U_3O_8 to be delivered in the form of a chemically produced) uranium concentrate meeting contract specifications as to physical characteristics, U_3O_8 grade, and impurities. The contracts did not include provisions for mill decommissioning, stabilization, or long-term management of milling process wastes (uranium mill tailings). When the contracts were executed, potential hazards of tailings were not fully recognized. During recent years, potential radiological and chemical hazards of tailings have been identified, and standards and requirements for management of tailings have been under development. Tailings stabilization and management requirements have changed since the termination of the AEC procurement contracts (see Appendix D). These requirements will increase the cost of total mill decommissioning at the 13 commingled sites over what the cost would have been when the AEC contracts terminated.

The first remedial action program related to uranium mill tailings was authorized by Public Law 92-314 on June 16, 1972. This program provides for remedial action for properties in the vicinity of Grand Junction, Colorado. As there were no restrictions to access the 2.2-million-ton tailings pile at Grand Junction, building contractors and individuals made extensive use of an estimated 300,000 tons of the tailings sands as construction or fill material before the practice was stopped in 1966. Under Title II of Public Law 92-314, Congress provides financial assistance to the State of Colorado to limit radiation exposure resulting from the use of uranium mill tailings for construction purposes. This state/Federal cooperative effort is conducted by the Colorado Department of Health pursuant to a cooperative agreement with the Department of Energy. The remedial action provides for removal of uranium mill tailings from the premises of an estimated 657 structures where external gamma radiation or indoor radon daughter exposure exceeds the Surgeon General's 1970 guidelines that were established as part of the implementation of Public Law 92-314. Federal funds cover 75 percent of the program costs, with the state providing the balance. Under the program, remedial action had been taken at 433 sites through fiscal year 1981. Program expenditures through fiscal year 1981 totaled approximately $12.5 million, and it is estimated that an additional $10.5 million will be required to complete the program by 1987.



SITE NO.	MILL	OWNER/CONTROLLER	LOCATION	RATED CAP.-TPD	MILL STATUS
1	Cotter Corp.	Cotter Corp.	Canon City, CO	1,500	Active
2	UCC-Uravan	Union Carbide	Uravan, CO	1,300	Active
3	Anaconda-Bluewater	Anaconda Minerals Co.	Bluewater, NM	7,000	Shutdown 3/82
4	Homestake	Homestake Mining Co.	Grants, NM	3,500	Active
5	Kerr-McGee	Kerr-McGee Nuclear Corp.	Ambrosia Lake, NM	7,000	Active
6	TVA-Edgemont	Tennessee Valley Auth.	Edgemont, SD	750	Shutdown 1974
7	Atlas	Atlas Minerals	Moab, UT	1,500	Active
8	Dawn	Newmont Mining Co.	Ford, WA	600	Active
9	Fed. American Partners	Fed. American Partners	Gas Hills, WY	950	Shutdown 11/81
10	Pathfinder Mines	Pathfinder Mines Corp.	Gas Hills, WY	2,800	Active
11	Petrotomics	Petrotomics Co.	Shirley Basin, WY	1,500	Active
12	UCC-Gas Hills	Union Carbide Corp.	Gas Hills, WY	1,400	Active
13	WNI-Split Rock	Western Nuclear Inc.	Jeffrey City, WY	1,700	Shutdown 6/81

Figure 1. Location of Licensed Uranium Mills Having AEC-Related Tailings Commingled with Tailings from Commercial Production

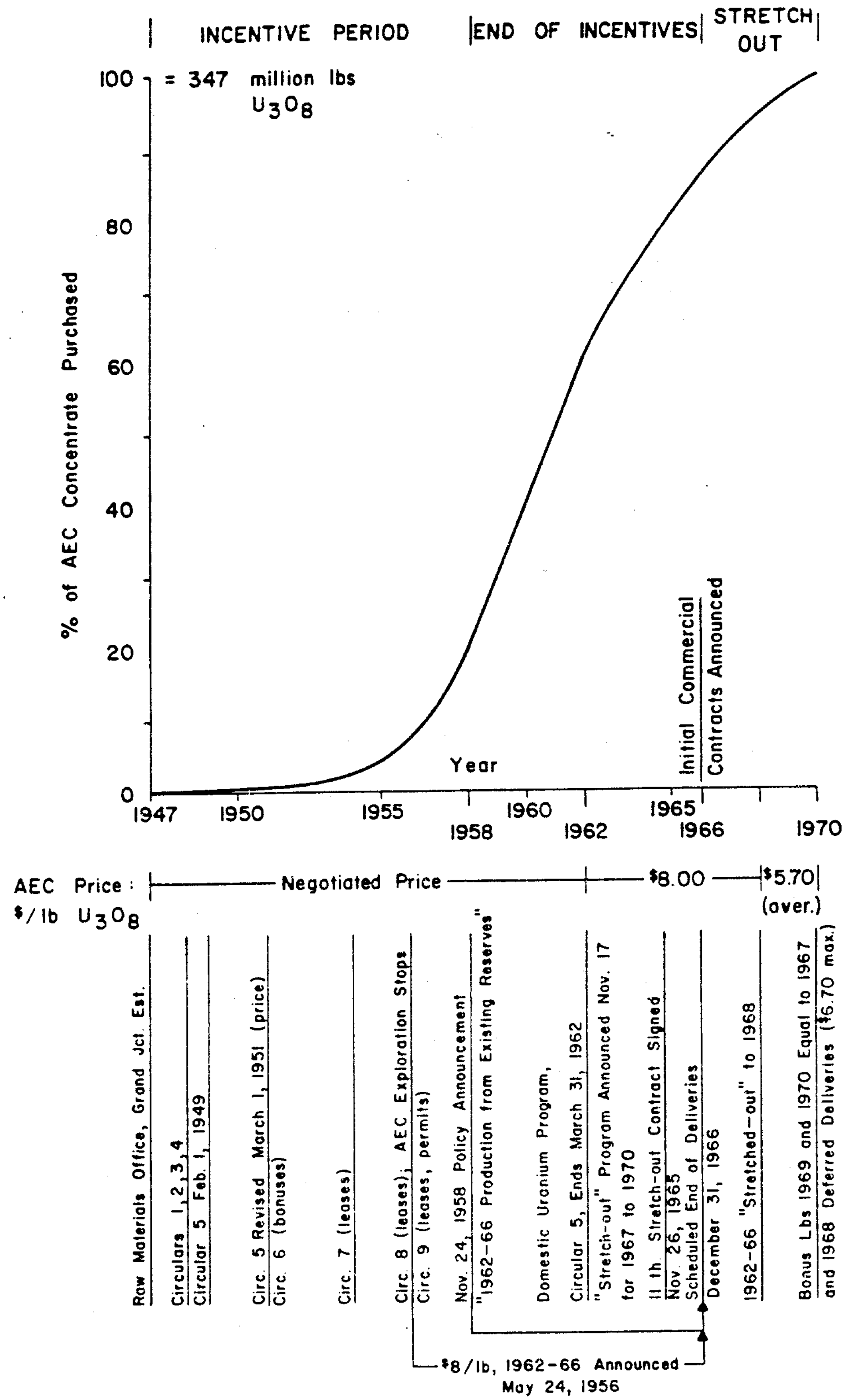


Figure 2. AEC Concentrate Purchase Program

Between 1975 and 1979, the successor agency to the AEC, the Energy Research and Development Administration (ERDA), completed studies for inactive uranium millsites that had produced uranium concentrate for the AEC, had subsequently ceased operations, and were considered inactive. In November 1978, Congress enacted Public Law 95-604, UMTRCA, which provides for the cleanup and stabilization of uranium mill tailings at 25 currently inactive uranium processing sites (where about 25 million tons of tailings were impounded) and at any vicinity properties contaminated with material derived from the sites. The mills at most of these sites produced uranium exclusively for the Federal Government. The program will be conducted under cooperative agreements between the Federal Government and the affected states, or Indian tribes where sites occur on tribal property. Remedial action costs will be shared on a 90-percent-Federal, 10-percent-state basis, except in the case of Indian tribes where the Federal Government will pay all costs.

During the hearings that preceded passage of Public Law 95-604, representatives of the uranium milling industry raised questions regarding Federal assistance for stabilization and management of commingled tailings at the active sites. Two reports were prepared for Congress' consideration of this matter. The first report, "Answers to Questions on Commingled Tailings at Currently Operating Uranium Ore Processing Mills That Produced Uranium Under Atomic Energy Commission (AEC) Contracts," DOE, January 29, 1979, acknowledged the basic inequity of having legislation (Public Law 95-604) providing Federal assistance to stabilize tailings produced under some Government contracts and not under others. The report also identified benefits accrued to the companies that might offset, to some degree, the unanticipated future costs of tailings stabilization. The DOE concluded that accurate cost estimates for stabilization of commingled sites could not be developed due to uncertainty of the standards and regulations to be developed by the Environmental Protection Agency (EPA) and the NRC and due to the lack of information on specific conditions at each site.

The second report, "Cleaning up Commingled Uranium Mill Tailings: Is Federal Assistance Necessary?" GAO, February 5, 1979, recommended that Congress provide assistance to the commingled millsite owners to share the cost of cleaning up that portion of the commingled mill tailings that was generated under Federal contracts.

Congress directed the Secretary of Energy, through Section 213 of Public Law 96-540, to detail relevant facts at each of the 13 sites, to culminate in a plan to provide Federal assistance in the stabilization and management of the commingled uranium tailings. Section 213 of the Law states:

> The Secretary of Energy shall develop a plan for a cooperative program to provide assistance in the stabilization and management of uranium mill tailings which have resulted from ore processing to extract uranium under contract with the United States for use primarily in defense programs and which are now commingled with other tailings. In developing the plan, the Secretary shall establish the amount and condition of the tailings resulting from such Federal contracts at each currently operating or currently licensed extraction site in order to permit calculation of the Federally contracted share of the total tailings which must be stabilized and managed over time. The plan shall include a methodology for

establishing the extent of Federal assistance appropriate to meet the costs for stabilizing and managing such tailings at each such site in order to comply with a requirement of Federal law or regulation imposed after termination of such Federal contracts. The Secretary shall consult with the owners and operators of each such site and shall submit the plan and his recommendations to the Armed Services Committees of the Congress not later than October 1, 1981. (Submission date subsequently extended to June 30, 1982.)

Recommendations regarding a Federal assistance program have been summarized under separate cover as Volume I. Volume II is a technical report summarizing site-specific details, alternative cost-sharing methodologies, and first-order estimates of Government costs for a cost-sharing program.

Section III

OBJECTIVES

The Grand Junction Area Office (GJAO) of the Department of Energy (DOE) was authorized to address technical aspects of the commingled tailings question in August 1981. A 40-week study was designed by GJAO with the following objectives:

1. Visit each of the 13 designated sites to (a) establish the quantity and condition of tailings resulting from Federal contracts, and (b) gather information relevant to long-term stabilization of the tailings.
2. Investigate reasonable cost-sharing approaches and present options for Congressional consideration of a Federal assistance program.
3. Consult with each mill operator, privately and through joint session, about alternative cost-sharing approaches.

Earlier studies, referenced in the Background section of this report, have addressed the question of whether or not Federal assistance is necessary. The working hypothesis of this study has been that a Federal assistance program may be enacted.

Visits to the tailings locations have contributed to 13 individual site reports, attached as Appendix A of this report and summarized in the following section. Cooperation in collecting and verifying information by the owner companies, essential to the timely production of the reports, has been excellent. Those companies which are members of the American Mining Congress (AMC), and which prepared reports at the request of an ad hoc committee of the AMC about their sites prior to DOE visits, further accelerated the data-gathering aspect of this study. Each company has had the opportunity to review and comment on the report concerning its site(s) prior to publication of this document.

The second objective of this study is to present and discuss cost-sharing options and the major issues surrounding each cost-sharing approach. Four general cost-sharing approaches have been considered. While each approach may have some merits, no single approach appears to be an obvious choice. In addition, each approach raises a secondary set of issues, which gives rise to further options. Those issues common to several possible approaches have been given most attention. Readers of this report may generate additional options not herein addressed, and omissions of such options from this report should not be construed as an indictment against their possible merits.

Private meetings were held at least once with each mill operator at their millsite(s) and/or company offices during the October 1981 to January 1982 period. All mill operators, as well as representatives of the American Mining Congress, were invited to attend joint study review meetings held in the DOE GJAO offices on January 21 and March 18, 1982.

Section IV

SUMMARY OF SITE REPORTS

BACKGROUND

Bendix Field Engineering Corporation (BFEC), under DOE contract, provided personnel and services in preparing this report and appendices. Five technical experts were retained to visit 13 millsites and prepare site reports and a history of the AEC Domestic Uranium Procurement Program.

Photographs were taken of the millsites and tailings impoundment areas at the time of the site visits. These and other visuals not conveniently reproducible are on file at the Grand Junction Area Office.

SUMMARY OF FINDINGS

Although the 13 commingled sites are similar in some respects, critical differences make each a unique case. Site-specific information supporting this conclusion has been assembled in Tables 6 through 9.

Table 6 lists general information concerning mill location, size, past and present ownership, and operation status. Production capacities of the 13 mills range from 600 to 7000 tons per operating day. Period of operation under AEC contracts ranged from 4 years at Petrotomics to 21 years at Union Carbide in Uravan. Four mills have undergone major shifts of ownership. Currently, nine mills are active, three have shut down, and one more will be shut down by the time of publication of this report.

Comparative features of the sites which may affect the eventual cost-sharing formula are shown in Table 7. All 13 mills were built at least partially in response to the AEC Domestic Uranium Procurement Program. Ten were built entirely for AEC production, while only portions of the Cotter and Union Carbide-Uravan plants were constructed for this purpose. The Federal uranium purchase program may have influenced construction of the Petrotomics mill, which was not built until the latter half of the program.

For various reasons, some tailings have been removed from the millsites. Kerr-McGee, for example, has used 1.2 million tons of tailings as mine backfill. However, the amount of tailings removed from the sites is negligible when compared to total tonnage generated. Only four mills produced other products (molybdenum, vanadium, and copper) during the contract period. At seven of the mills, all AEC-related tailings are physically commingled with tailings generated by commercial production; six mills have at least one pile or pond that contains only AEC-related tailings. At only one of these six, Dawn, are all AEC tailings entirely segregated from tailings generated under commercial contracts. Other features listed in Table 7 serve to highlight dissimilarities among the sites.

The "tailings-to-be-moved" topic is highly speculative. While 11 mill owners have no license requirement to move the piles prior to stabilization, some

Table 6. Mill Ownership and Status

Mill/Location	Estimated Capacity (TPD)	Ownership During Deliveries Under AEC Contract (period)	Parent Ownership	Mill Status
Cotter Corporation Canon City, Colo.	1500	Cotter Corp. (1958-1965)	Commonwealth Edison Co.	Active
Union Carbide Uravan, Colo.	1300	Union Carbide Corp. (1949-1970)	Union Carbide Corp.	Active
Anaconda Minerals Co. Bluewater, N. Mex.	7000	Anaconda Copper Co. (1953-1970)	Atlantic Richfield Co.	Shutdown, 3/82
Homestake Mining Co. Grants, N. Mex.	3500	Homestake-NM Partners to 1961 Homestake-Sapin Partners to 1968 United Nuclear-Homestake Partners after 1968 (1957-1970)	Homestake Mining Co.	Active
Kerr-McGee Nuclear Corp. Ambrosia Lake, N. Mex.	7000	Kermac Nuclear Fuels Corp. (1958-1969)	Kerr-McGee Corporation	Active
TVA Edgemont, So. Dak.	750	Mines Development, Inc. (1956-1968)	Tennessee Valley Authority	Shutdown, 1974
Atlas Minerals Division Moab, Utah	1500	Uranium Reduction Co. to 1962 Atlas Minerals (1956-1970)	Atlas Corporation	Active
Dawn Mining Company Ford, Wash.	600	Dawn Mining Co. (1957-1965)	Newmont Mining Corporation	Active
Federal-American Partners Gas Hills, Wyo.	950	Federal-Radorock-Gas Hills Partners (1959-1969)	Federal-American Partners	Shutdown, 11/81
Pathfinder Mines, Inc. Gas Hills, Wyo.	2800	Utah Construction and Mining Company, later known as Utah International (1958-1970)	Pathfinder Mines, Inc.	Active
Petrotomics Company Shirley Basin, Wyo.	1500	Kerr-McGee-Getty Partnership (1962-1966)	Getty Oil Company	Active
Union Carbide Corp. Gas Hills, Wyo.	1400	Union Carbide Corp. (1960-1970)	Union Carbide Corp.	Active
Western Nuclear, Inc. Jeffrey City, Wyo.	1700	Lost Creek Uranium Western Nuclear Corp. to 1959 Western Nuclear, Inc. (1957-1969)	Phelps Dodge Corp.	Shutdown, 6/81

Table 7. Comparative Features of Commingled Tailings Sites

Mill/Location	Has at Least One All-AEC Pond or Pile On-Site	Tails Lost or Moved Off-Site	Other Products[a]	Tails Reprocessed Commercially	Significant U_3O_8 Inventory at End of Contracts	Current Plans for Tails To Be Moved	Mill Built for AEC Contracts
Cotter/Colo.	No	No	None	No	No	Yes	1st mill
Union Carbide/Colo.	Yes	Yes	V	Yes	No	No	"B" Plant
Anaconda/N. Mex.	Yes	No	None	No	Yes	No	Yes
Homestake/N. Mex.	Yes	No	V	No	Yes	No	Yes
Kerr-McGee/N. Mex.	No	Yes	Mo	No	Yes	No	Yes
TVA/S. Dak.	Yes	Yes	V and Mo	Yes	No	Yes	Yes
Atlas/Utah	No	No	V and Cu	No	No	Possibly	Yes
Dawn/Wash.	Yes	No	None	No	No	No	Yes
Federal American Partners/Wyo.	Yes	No	None	No	Yes	Possibly	Yes
Pathfinder/Wyo.	No	No	None	No	Yes	No	Yes
Petrotomics/Wyo.	No	No	None	No	Yes	No	Possibly
Union Carbide/Wyo.	No	No	None	No	Yes	No	Yes
Western Nuclear/Wyo.	No	No	None	No	Yes	No	Yes

[a]Refers to AEC contract period only.

officials with these companies feel that NRC may require relocation of the tailings after mill closure. Cotter is transferring its commingled pile to a new lined impoundment area in compliance with a license condition, and TVA is planning for remote disposal of tailings from the Edgemont site. Other companies have indicated that regulatory agencies may require that tailings be moved prior to final stabilization.

Table 8 compares the amounts of tailings involved and the areal extent of solid tailings disposal. Kerr-McGee, Homestake, and Anaconda hold by far the largest amounts of AEC-related tailings. In terms of total tonnage of tailings, both AEC-related and commercial, Kerr-McGee has the largest tailings pile, with the Anaconda pile a close second. Tailings impoundments at Anaconda and Kerr-McGee cover the greatest area of the 13 millsites at 341 acres and 328 acres, respectively. Tailings at the Uravan facility cover less than 85 acres.

Information concerning the source material license for each mill and environmental issues discussed in the site reports are summarized in Table 9. Seven of the commingled tailings sites are located in states which have no agreement with the NRC concerning licensing of source material (South Dakota, Utah, and Wyoming) and are, therefore, subject to regulation by the NRC. Six mills are located in the Agreement States of Colorado, New Mexico, and Washington. At this time, eight mill licenses are current. Five mills are operating under "timely renewal" provisions which allow a mill to continue operations under an expired license after filing a renewal application prior to 30 days before expiration of the license.

Table 9 also summarizes certain environmental issues pertinent to the specific sites. At several sites, potential problems with surface- and/or ground-water contamination are of concern. Significant environmental problems have a bearing on stabilization cost.

Table 8. Size of Tailings Impoundments

Mill	Tailings in Piles as of 12/31/81 (millions of tons)			Solid Tailings Impoundment Area (acres)
	Under AEC Contracts	Under Commercial Contracts	Total	
Cotter	0.315	1.615	1.930	165
UCC-Uravan	5.701	4.176	9.877	85
Anaconda	8.837	14.749	23.586	341
Homestake	11.411	9.734	21.145	210
Kerr-McGee	10.032	20.381	30.413	328
TVA	1.625	0.410	2.035	123
Atlas	5.946	4.219	10.165	128
Dawn	1.171	1.769	2.940	133
Fed.-Am. Partners	2.081	3.800	5.881	117
Pathfinder	2.842[a]	6.672	9.514	248
Petrotomics	0.725	4.821	5.546	140
UCC-Gas Hills	2.103	5.142	7.245	146[b]
WNI	3.347	4.350	7.697	167
Totals	56.136	81.838	137.974	2331

[a]Includes 168,000 tons of heap-leaching residues.

[b]Inoperative pile only; contains commingled AEC-related tailings.

Table 9. Summary of Licensing and Environmental Issues

Mill/Location	Licensing Authority	Status of License	Issues
Cotter/Colo.	State of Colorado	Current	Allegations of ground-water contamination; extensive ground-water monitoring program in progress.
Union Carbide/Colo.	State of Colorado	Operating Under Timely Renewal	Interim stabilization to improve stability and seepage collection has cost $11.6 million.
Anaconda/N. Mex.	State of New Mexico	Current	Seepage from main pond exceeds State of New Mexico standards although company maintains problem is not serious.
Homestake/N. Mex.	State of New Mexico	Operating Under Timely Renewal	Dust control for tailings: $70,000-$90,000 each application. Ground-water contamination detected; entered into ground-water protection plan with State of New Mexico. Purchased half-mile zone around site for $2 million.
Kerr-McGee/N. Mex.	State of New Mexico	Operating Under Timely Renewal	Seepage from unlined ponds; company maintains problem is not serious at present.
TVA/S. Dak.	NRC	Current	Alluvial ground-water contamination detected. Site may be responsible for elevated radon levels off-site. Flooding potential at present site.
Atlas/Utah	NRC	Current	Additional riprap along Moab Canyon wash dike may be required by NRC for erosion control.
Dawn/Wash.	State of Washington	Operating Under Timely Renewal	Some seepage from piles not exceeding allowable parameters. Windblown tailings have been problem, but covering piles should alleviate it.
Fed.-Am. Partners/Wyo.	NRC	Operating Under Timely Renewal	Potential windblown contamination, but effects of Fed.-Am. Partners alone have not been determined. Fed.-Am. Partners has spent $4.2 million revising tailings management plan which has not yet been approved.
Pathfinder/Wyo.	NRC	Current	
Petrotomics/Wyo.	NRC	Current	
Union Carbide/Wyo.	NRC	Current	Tailings seepage may be contaminating surface water in vicinity. Minor contamination from windblown tailings is possibility.
Western Nuclear/Wyo.	NRC	Current	Past problems with tailings release although contamination has been contained within WNI property boundaries.

Section V

COMMINGLED URANIUM MILL TAILINGS INVENTORIES

ESTABLISHING AEC-RELATED TONS OF TAILINGS

In considering a cost-sharing approach based on tonnage, defining the quantity of AEC-related tailings becomes imperative. The basic data on "tonnage" are the ore weigh-in records at the millsite, labeled "ore fed to process." Both company and AEC records of these quantities have been kept. However, questions have arisen as to whether "tons of ore fed to process" (which can be considered equivalent to tons of tailings) should be adjusted for the following factors:

1. A portion of the uranium produced was sold commercially or inventoried. Are records of tonnage and pounds U_3O_8 produced adequate to trace specific quantities of concentrate production to purchases by the AEC or by commercial buyers?

2. Some uranium was produced from mine waters, in-situ leaching, or heap-leach liquors and had no solid tailings associated with its production. What portion of AEC-purchased uranium came from these sources?

3. Ore was toll-milled at many of the subject sites during the contract period, with the ultimate purchaser of the U_3O_8 unknown. Did toll ore result in "AEC-related" or "commercial" tailings?

4. Tailings may have been removed from the site for mine backfill or other purposes. Tailings from early production may have been lost to past flood, dam, or dike failures. Tailings may have been (or will be) reprocessed after the AEC purchase period. Should subtractions to AEC-related tailings be made to adjust for any or all of these events?

5. Depending upon the chemical process and type of ore, 1 ton of ore can result in slightly more or slightly less than 1 ton of tailings, due to dissolution of uranium oxides and other minerals, or a gain from process additives. What is the tailings equivalent to 1 ton of dry ore?

6. Certain millsites have various tailings piles, some of which are commingled, all commercial, or all AEC-related. Should different piles be treated (cost-shared) differently?

7. How should heap-leach dumps, which may be on or off the millsite, be regarded? Heap-leaching leaves piles similar to conventional tailings.

For the purposes of this report, the following assumptions have been made:

1. Records are not adequate in all cases to trace specific U_3O_8 concentrate purchases to specific ores. Concentrate produced for sale to the AEC is assumed to have been produced from "average" grade ore for the contract period, not high- or low-grade ore.

2. Specific purchases of U_3O_8 cannot be traced to specific sources, i.e., mine water, leach liquor, or ore. AEC-purchased materials are assumed to have been derived in the same proportion from all sources.

3. Where records do not exist, the U_3O_8 derived from toll-milled ore is presumed to have been sold to the AEC or others in the same ratio as U_3O_8 derived from company-owned ore. Where purchases of concentrate derived from toll-milled ore can be traced to the AEC, actual ratios are used.

4. Tailings reprocessed after the end of the AEC purchase program could be considered AEC tailings that have been converted to commercial ore, and then to commercial tailings. Hence, the quantity of AEC-related tailings could be reduced in the future. Similarly, tailings used for mine backfill have been subtracted from the quantity of tailings derived from "ore-fed-to-process" figures because of the benefits accruing from mine backfilling practices. Mine backfilling results in improved ore extraction, a safer underground environment, prevention of surface subsidence, and mixing of waters in various aquifers. The primary concern is with the tonnage of AEC-related tailings actually commingled in large piles requiring stabilization.

   Tailings which have been lost should theoretically be subtracted as well. However, it is rarely possible to estimate this quantity with reasonable accuracy, or even to prove qualitatively that significant losses have occurred. Where losses have likely occurred, estimates of the quantity of remaining tons of tailings in the pile are utilized instead of ore-fed-to-process figures.

5. One ton of dry ore is presumed to produce one ton of dry tailings.

6. Tailings in noncommingled (AEC-only and commercial-only) piles are expected to be handled separately. In no case should costs be shared for stabilization of commercial-only piles. Unless otherwise noted, cost estimates for reclamation of commingled tailings have excluded tailings in commercial-only piles.

7. Heap-leach piles generated during the AEC purchase program are regarded as commingled tailings piles, whether on or off the millsite.

Three additional issues have been raised where two options have been investigated. These issues are:

1. Should the tonnage attributable to AEC contracts be determined for the entire AEC concentrate purchase program (through 1970), or be based on an earlier cutoff date when military needs may have been satisfied and the Government may have become a surrogate "commercial" buyer in lieu of a coming commercial market?

2. Coproduct or byproduct vanadium, molybdenum, copper, and other metals were at times recovered from the ore, as well as uranium. Should a portion of the tailings be allocated to these products, which were sold largely on the commercial market?

3. Company and AEC records concerning "ore fed to process" for the contract periods are not in perfect agreement. Whose figures should be used in computing official tonnage ratios?

The following options for these issues have been considered:

1. In addition to using the entire AEC concentrate purchase program, which terminated December 31, 1970 (the base case), a cutoff date of December 31, 1968, has also been chosen to generate figures (Option 1) for AEC-related tonnage. This date marked the beginning of the Government purchase of "bonus" pounds of U_3O_8 from companies which voluntarily participated in the "stretch-out" program announced in November 1962.

2. Most byproducts recovered with uranium during the AEC concentrate purchase program were removed from the mill circuit to meet the AEC chemical specifications for uranium concentrate or for process control reasons. As the primary incentive for recovery of these metals was not profit, it is appropriate to disregard byproduct production in most instances.

   A possible exception is the recovery of vanadium oxide (V_2O_5). Two mills, at Uravan, Colorado, and Edgemont, South Dakota, recovered large quantities of vanadium from uranium ore, or, in the case of Edgemont, ore, slimes, and vanadate slags. A portion of the vanadium produced at Uravan was purchased by the AEC, which guaranteed a market for far more vanadium than it actually purchased. However, if some portion of the vanadium produced is considered to be "for commercial purposes," a portion of the tailings could be allocated to its production.

3. In this report, the authors chose to use Government or company figures for "tons ore fed to process," depending upon GJAO assessments of which figures were likely to be more reliable. In either case, the other figure is also available in the site report.

Table 10 summarizes tons of AEC-related tailings at each site as of December 31, 1981, for the base case. The base case reflects all assumptions cited earlier, considers the entire AEC concentrate purchase program, and does not attempt to adjust the tonnage of tailings for coproduct or byproduct production. Hence, the base case produces the maximum quantity for AEC-related tailings.

Table 11 summarizes tons of AEC-related tailings at each site as of December 31, 1981, for Option 1. Option 1 is based on the argument that AEC procurement of uranium for defense purposes was scheduled to conclude in 1966 but was later extended to year-end 1968. The Government formally recognized in a November 1958 announcement that its needs would be met from deposits already discovered, and established an allocation program for production through 1966 to meet those needs. In 1962, it was apparent that the private market for uranium concentrates would not be sufficient to sustain a viable domestic uranium industry as of the end of 1966, and a voluntary "stretch-out" program was announced. The Government commitments for the purchase of uranium during the 1962-1966 period were "stretched" over the 1962-1968 period, and participating companies were allowed to deliver "bonus" pounds of concentrate in 1969 and 1970 equal to the deferred deliveries of 1967 and 1968. About 17 million pounds (5 percent) of the total 347 million pounds U_3O_8 purchased by the Government in the 1947-1970 period were delivered in 1969 and 1970.

Table 10. Base Case: Derivation of Tailings Attributable to AEC Uranium Concentrate Purchases That Originated from Ore (As of the End of Uranium Concentrate Deliveries to AEC)

Mill	Tons: Ore Fed to Process B	Tons: Tailings Used as Mine Backfill F	U_3O_8 in Conc. (lbs.): AEC Purchases X	U_3O_8 in Conc. (lbs.): Total Production Y	Tons of Ore Tailings Attributable to AEC Uranium Conc. Purchases[a] (B-F) (X/Y)	Portion of Tailings Shown in Prior Column (tons): In Piles Containing "AEC-Only" Tailings	Portion of Tailings Shown in Prior Column (tons): In Piles Containing Commingled Tailings
Cotter	319,400	0	3,142,980	3,196,597	314,043	0	314,043
UCC-Uravan	5,878,778	0	23,857,710	24,619,976	5,696,764	497,142	5,199,622
Anaconda	10,032,560	0	39,649,636	45,014,024	8,836,965	795,326	8,041,639
Homestake	12,531,127	0	42,252,177	46,355,200	11,421,964	1,256,416	10,165,548
Kerr-McGee	11,948,899	598,200	43,302,213	48,997,213	10,031,395	0	10,031,395
TVA	1,643,148	0	6,072,502	6,142,704	1,624,369	500,000[b]	1,124,369[b]
Atlas	6,394,000	0	38,500,282	41,477,839	5,934,996	0	5,934,996
Dawn	1,171,313	0	5,279,675	5,314,770	1,163,578	1,163,578	0
Federal	2,676,313	0	6,954,100	8,942,190	2,081,296	500,000[b]	1,581,296[b]
Pathfinder	3,489,317	0	16,748,202	21,912,119	2,673,514[c]	0	2,673,514[c]
Petrotomics	786,928	0	3,383,821	3,672,925	724,987	0	724,987
UCC-Wyoming	2,463,809	0	5,617,289	6,579,903	2,103,363	0	2,103,363
Western Nuclear	3,544,542	0	14,935,569	15,818,793	3,346,637	0	3,346,637
Totals	62,880,134	598,200	249,696,156	278,044,253	55,953,871	4,712,462	51,241,409

[a]Because grades of ore fed have been averaged over a period of time, figures listed here may differ from those presented in site reports. "Tons of tailings" used in order-of-magnitude cost estimations have been rounded to the nearest 100,000 tons.

[b]Tailings located in both "AEC-only" and commingled piles; figures are estimations because exact distribution is unknown.

[c]Excludes heap-leach residues.

Table 11. Option 1: Derivation of Tailings Attributable to AEC Uranium Concentrate Purchases That Originated from Ore (as of December 31, 1968)[a]

Mill	Tons		U_3O_8 in Conc. (lbs.)		Tons of Tailings Attributable to	Portion of Tailings Shown in Prior Column (tons)	
	Ore Fed to Process B	Tailings Used as Mine Backfill F	AEC Purchases X	Total Production Y	AEC Uranium Conc. Purchases (B-F) (X/Y)	In Piles Containing "AEC-Only" Tailings	In Piles Containing Commingled Tailings
Cotter[b]	319,400	0	3,142,988	3,196,597	314,043	0	314,043
UCC-Uravan	5,116,901	0	21,526,851	21,799,142	5,054,860	497,142	4,557,718
Anaconda	8,963,417	0	36,639,784	38,437,163	8,544,274	765,033	7,779,241
Homestake	10,775,786	0	38,509,913	40,641,121	10,205,739	1,241,774	8,963,965
Kerr-McGee	10,620,802	576,918	40,279,486	45,294,968	9,064,470	0	9,064,470
TVA[b]	1,643,148	0	6,072,502	6,142,704	1,624,369	-[c]	-[c]
Atlas	5,757,084	0	37,186,576	39,137,991	5,470,037	0	5,470,037
Dawn[b]	1,171,313	0	5,279,675	5,314,770	1,163,578	1,163,578	0
Federal	2,087,065	0	6,629,861	7,087,616	1,952,272	482,801	1,469,471
Pathfinder	2,680,454	0	14,818,383	17,311,724	2,294,399	0	2,294,399
Petrotomics	786,928	0	3,383,821	3,672,925	724,987	0	724,987
UCC-Wyoming	1,748,896	0	4,859,289	4,926,083	1,725,182	0	1,725,182
Western Nuclear	3,419,214	0	14,397,759	15,340,687	3,209,049	0	3,209,049
Totals	55,090,408	576,918	232,726,888	248,303,491	51,347,259	4,650,328	46,696,931

[a]These figures have been derived for DOE estimating purposes; their accuracy has not been confirmed by the mill owners.

[b]These mills were not involved in the stretch-out program.

[c]Tailings located in both "AEC-only" and commingled piles; exact distribution unknown.

The nine mills in this study which participated in the "stretch-out" program delivered about 16.5 million pounds, or 95 percent of the 1969-1970 deliveries. If tailings generated for "bonus pound production" are excluded, the base-case quantity of AEC-related tailings is reduced by 7 percent.

ADJUSTMENTS FOR COPRODUCTS AND BYPRODUCTS

Nearly all uranium ores contain traces of other metals, some of which have been recovered on a small scale. These metals include molybdenum, selenium, copper, silver, scandium, thorium, ionium, protactinium, and radium. Some ores, especially those of the Uravan Mineral Belt, contain significantly more vanadium than uranium. In fact, 8 of the 34 mills that produced uranium for sale to the AEC recovered vanadium as a coproduct. A few other mills recovered small amounts of vanadium as a byproduct. Of the 13 mills included in this study, 4 mills recovered vanadium and 3 mills recovered other byproducts during the term of AEC contracts. As noted elsewhere, some byproduct recovery was accomplished primarily for process control and to meet uranium concentrate specifications for sales to the AEC. In these instances, byproduct recovery and sales, especially of vanadium and molybdenum, were minimal and of questionable profitability.

Regarding those mills where substantial quantities of coproducts or byproducts were produced and marketed during the term of AEC contracts, the question arises as to whether or not consideration should be given to adjusting the quantity of tailings attributable to the AEC contracts for production other than U_3O_8. One possible method for making this adjustment is to relate the value of coproducts or byproducts to that of the U_3O_8. For example, fused V_2O_5 sold for about \$1 per pound while U_3O_8 sold to the AEC averaged about \$8 per pound. Then, 8 pounds of V_2O_5 produced could be considered the equivalent of 1 pound U_3O_8. The basic formula $\frac{A}{B} \times C = D$ would then be defined as follows:

A = pounds U_3O_8 purchased by the AEC, plus pounds equivalent U_3O_8 of V_2O_5 purchased by the AEC.
B = total U_3O_8 production during periods of AEC contracts, plus pounds equivalent U_3O_8 of V_2O_5 produced during the same periods.
C = total tons of ore fed to process during periods of AEC contracts.
D = tons of tailings attributable to AEC contracts.

Similarly, A and B could be defined to include other byproducts by assuming an equivalent value such as:

1 pound Mo equivalent to 1/2 pound U_3O_8.
1 pound Cu equivalent to 1/20 pound U_3O_8.

In this study, only the coproduct vanadium from two mills was produced in sufficient quantity to consider an adjustment to the amount of tailings attributable to the AEC contracts. In the case of Union Carbide, Uravan, the quantity of tailings attributable to the AEC contract would be adjusted downward from 5.7 million to 4.3 million tons using an 11.4:1 V_2O_5 to U_3O_8 equivalence for prices paid Carbide during the period of the AEC contract. This adjustment assumes a maximum possible V_2O_5 production [actual records are unavailable and vanadium was held in an intermediate unfinished state (ferric vanadate) for much of the contract] and results in a minimal value for AEC-related tons. At the other mill, TVA, Edgemont, adjustment for V_2O_5 production would reduce the quantity of tailings attributable to the AEC contract from 1.6 million to about 1.5 million tons.

Calculated adjustments for other byproducts at all other mills showed negligible change in the quantity of tailings attributable to AEC contracts. In most instances, these calculations had to be based on estimated byproduct production and sales, as few records of the activity still exist.

Arguments against adjustments for coproducts or byproducts recovered by the mills in this study include, but are not limited to, the following:

1. The AEC encouraged vanadium production in order to get uranium, and, in its earliest contracts, the AEC even provided a market for excess V_2O_5 that could not be sold commercially. Because the market became saturated and remained so, especially while the Government disposed of its vanadium stocks, it is unclear whether or not vanadium was profitably produced and sold during the AEC program period.

2. The price paid by the AEC for U_3O_8 took into account coproduct production at the time the U_3O_8 price was negotiated, in effect reducing the price the AEC would have otherwise paid had coproducts not been produced.

3. The remedial action program for the inactive millsites makes no distinction as to whether or not coproducts or byproducts were recovered. In fact, vanadium and/or other products were produced at about one-half the inactive sites.

ESTABLISHING AREAS FOR AEC-RELATED TAILINGS

One approach considered in this study is that the Government should share costs of tailings stabilization on the basis of acres of ground surface disturbed rather than on a proportionate share of the quantity or tonnage of tailings attributable to AEC contracts since the principal costs of tailings stabilization are area dependent. At Dawn (Ford, Washington), TVA (Edgemont, South Dakota), Federal-American Partners (Gas Hills, Wyoming), and Anaconda and Homestake (Grants, New Mexico), some of the tailings attributable to the AEC contract period were impounded separately and remain isolated from other tailings. In these instances, the mill owners suggested that these piles should be stabilized at no cost to the mill owners.

At these and others of the millsites are areas of commingled tailings, often with the AEC-related portion situated at the bottom of the piles. Where only one or two areas have been used for impounding tailings since mill start-up, the tailings area has increased only slightly as the height of the pile has increased. This is the case at Atlas (Moab, Utah), Kerr-McGee (Ambrosia Lake, New Mexico), Union Carbide (Uravan, Colorado), and Homestake (Milan, New Mexico).

Table 12 summarizes the area (acreage) figures which may be relevant in devising a cost-sharing plan based on acreage ratios. (Table 12a provides explanatory notes relating to the data presented in Table 12.) Further investigation would be necessary to acquire complete and definitive data. While industry considers that these proposals would be equitable cost-sharing approaches, they could result in the Government paying for a greater share of the costs than would be calculated on a tonnage basis.

Table 12. Acreage Affected by AEC Tailings (12/31/81)

Mill/Location	Surface Area Covered by Ponds or Piles (acres)			Interim Stabilization Done (acres)	Surface Disturbance Directly Attributable to AEC Tailings	
	Solution and/or Evaporation Ponds	Solid Tailings Impoundment Areas	Total		Acres	Percent of Solid Tailings Impoundment Areas Directly Attributable to AEC Tailings
Cotter/Colo.	10[a]	165	175	–[a]	74	100
Union Carbide/Colo.	36[a]	85	121	–[a]	85[a]	100
Anaconda/N. Mex.	292	341	633	71[a]	341[a]	100
Homestake/N. Mex.	0	210	210	20[a]	188[a]	90
Kerr-McGee/N. Mex.	395	328	723		288[a]	88
TVA/S. Dak.	0	123	123	83[a]	123[a]	100
Atlas/Utah	3	128	131	–[a]	118[a]	92
Dawn/Wash.	0	133	133	90[a]	59[a]	100; 44
Fed.-Amer. Partners/Wyo.	0	117	117		117	100
Pathfinder/Wyo.	229	248	477	–[a]	97[a]	100; 39
Petrotomics/Wyo.	0	140	140		140[a]	100
Union Carbide/Wyo.	–[a]	146[a]	146	–[a]	60[a]	41
WNI/Wyo.	0	167	167		83	50
Totals	965	2331	3296	264	1773	

[a]See Table 12a for comments.

Table 12a. Acreage Affected by AEC Tailings: Explanation

Mill/Location	Comments
Cotter/Colo.	10 acres of previously used unlined solution ponds. All AEC-related tailings located at bottom of Pond 1 (30 acres); extent of coverage unknown. Tailings in Pond 1 are being transferred to Pond 3 (43.5 acres) which will then be temporarily stabilized until mill closure. Percent disturbance does not include commercial-only main impoundment (91 acres).
Union Carbide/Colo.	36 acres in Club Ranch Ponds only; does not include Club Mesa evaporative spray area. Interim stabilization done on Piles 2 and 3; no acreage given. Sludge-pond Pile (4.5 acres) used exclusively for AEC tailings between 1950 and 1956; exact coverage in remaining commingled piles unknown, but assumed to completely underlie impoundments.
Anaconda/N. Mex.	Inactive Carbonate pile (47 acres) and North Area Acid pile (24 acres), both containing only AEC tailings, covered with 30 inches of soil. AEC tailings commingled over 270 acres in Main Pond are assumed to completely underlie impoundment.
Homestake/N. Mex.	Interim stabilization of approximately 20 acres of AEC pile with several feet of contaminated soil and junk; has been vegetated. Tailngs are in two piles, one entirely AEC-generated (40 acres) and the other commingled (170 acres); extent of coverage of AEC tails in commingled pile unknown, but is roughly 13% less than area of present pile.
Kerr-McGee/N. Mex.	Total area of tailings and evaporation ponds in 1967 was 539 acres, roughly the same acreage as in 1970 at the end of the Government contract, with solid tailings only covering approximately 288 acres.
TVA/S. Dak.	Revegetation on 83 acres. Ponds 1 and 2 (approximately 16 acres) used for AEC slimes only during 1950-1956. Rest of tailings commingled; AEC-related assumed to underlie all impoundments.
Atlas/Utah	At the end of the AEC purchase program (12/31/70), AEC tailings accounted for 93 percent of pile; at that time 118 acres were covered by the tailings impoundment. Extent of interim stabilization at this time unknown.
Dawn/Wash.	Approximately 90 acres have been covered by wood chips or dirt. All AEC-related tailings are located in Ponds 1 and 2, and are not commingled. AEC-related tailings cover 44% of total impoundment areas or 100% of area if not considering commercial-only piles.
Fed.-Amer. Partners/Wyo.	Some vegetation on dikes of Pond 1 for dust control.
Pathfinder/Wyo.	AEC-related tailings in Pond 1 (44 acres) and 2 (53 acres). Percent coverage of AEC-related tailings is 100 if commercial-only areas not included.
Petrotomics/Wyo.	All tailings commingled in one pond. Exact coverage of AEC-related tailings unknown, but assumed to completely underlie impoundment.
Union Carbide/Wyo.	Post-1970 evaporation ponds exist; no acreage available. Tailings in two piles; only the inoperative pile (146 acres) contains AEC tails. No acreage given for operative pile. Extent of interim stabilization done unknown. Prior to 1971, commingled tailings covered 60 acres. Percent based on inoperative pile.
Western Nuclear/Wyo.	

Section VI

POTENTIAL COST FACTORS

Costs associated with management of uranium mill tailings fall into two major categories: costs incurred during embankment-systems construction and operation, and costs incurred after plant shutdown. Costs incurred during construction and operation of the mill prior to shutdown, other than interim stabilization, are not the primary subject of this study and will not be addressed in detail.

After mill shutdown, costs may be further divided into two subcategories, namely short-term costs associated with tailings stabilization and decommissioning requirements, and long-term costs incidental to the surveillance, monitoring, and maintenance of the stablized tailings piles.

SHORT-TERM COSTS

Following mill shutdown, or earlier, the tailings must be stabilized by a method which meets current Government regulatory requirements of either the NRC or the regulations of the applicable Agreement State. Final EPA environmental and health standards for stabilization have not yet been promulgated. NRC Uranium Mill Licensing Requirements issued on October 3, 1980, have been suspended by Congress and are the subject of court actions.

The principal goal of tailings disposal and stabilization programs under NRC regulations is to isolate radioactive tailings from the environment for as long as reasonably possible while committing future generations to a minimum amount of maintenance.

To ensure effective isolation of the material under these regulations, several objectives must be met in the final stabilization of the tailings:

1. Prevention of degradation of water quality.
2. Reduction of radon emanation to levels of less than $2 pCi/m^2$-sec above natural background.
3. Prevention of degradation of cover materials by natural forces or human activity.

A combination of techniques may be applied to accomplish the objectives listed above. They include, for example, below-grade disposal, use of synthetic or clay liners, caps, thick soil (NRC standard of 3 meters minimum) and clean rock covers, revegetation, and chemical treatment of the tailings. These aspects of tailings management are discussed in detail in the NRC Final Generic Impact Statement on Uranium Milling (NUREG-0706) and in the EPA Draft Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192).

Short-term costs may include those associated with requirements to minimize erosion and restrict access by contouring, covering, and stabilizing the tailings pile, and fencing the site. Average unit costs to meet these requirements have been estimated by EPA (updated to 1980 dollars) at \$0.29/yd^3 for spreading and compaction of tailings; \$1.02/yd^3 for haulage up to 1 mile, dumping, spreading, and compaction of soil; and \$9.05/ft for fencing.

For costs used in NUREG-0706, the NRC staff assumed a unit cost of \$1.34/yd^3 to install cover material, which included excavating, hauling, and compacting the material, and the reclamation of the borrow pits. The "as-low-as-possible" Guides for Milling of Uranium Ores, prepared by Oak Ridge National Laboratory (ORNL) for the NRC in 1975, estimated tailings management costs of \$510 per acre per foot of earth cover (\$745 in 1980 dollars). Other costs of this type adopted by the NRC staff in the NUREG-0706 are presented in the following table.

Table 13. Unit Costs Used in Evaluations[a]

Factor	Selected Values (1980 dollars)
Excavate, Load, and Haul ($\leq$ 1 km) Deposit	0.92/yd^3
Truck Transport ($\geq$ 1 km)	0.33/yd^3-mi
Spreading and Compacting (cover and fill)[b]	0.96/yd^3
Compacting Soil Already in Place	10,500/acre
Installation of Clay Liner[b]	1.95/yd^3
Installation of Cover Material	1.34/yd^3
Installation of Hypalon Liner (30 mil)	0.64/ft^2
Installation of PVC Liner (30 mil)	0.46/ft^2
Resurfacing and Revegetation	2020/acre

[a]Only those costs common to alternatives are listed.

[b]Installation of liner or dam, and hence degree of compaction, must meet more stringent quality assurance and testing requirements than cover or fill materials.

Costs for covering tailings disposal areas are dependent on a number of site-specific factors: the radon attenuation properties of the cover material, which determines the amount of cover material needed; the availability of cover materials; the area of the tailings piles; the residual radium content of the tailings; and the distribution of sands and slimes in the tailings disposal area. Enforcing the NRC requirement for final tailings pile slopes of 10h to lv would necessitate spreading tailings over larger areas before covering.

For a given volume of tailings, the surface area to be covered depends on the depth of the tailings pile. It has been estimated that if a common soil were used, the costs of covering tailings produced by an average 2000-ton-per-day mill over its life (a depth of about 26 feet and an exposed area of 200 acres) would be $4.5 million. If the thickness of the tailings were increased to 52 feet, and the area proportionately reduced, then the cost of the tailings covering would decrease to about $2.2 million. Similarly, tailings covering costs would almost double ($9 million) if the tailings pile thickness were halved to 13 feet.

There are many variations with respect to acres of tailings areas and depths of piles at the 13 sites being studied, and data on the areal extent of AEC-related tailings as opposed to commercial tailings in commingled piles are not as complete as is the information on tons of tailings.

Decommissioning implies that, at the conclusion of operations of the mill, it will be dismantled and decontaminated. Two alternative modes of decommissioning are currently being considered by the NRC. These are (1) the decontamination, retention, and reuse of some or all of the buildings and equipment; and (2) the complete removal of all buildings, foundations, and equipment, and restoration of the site to its approximate original state. Decontamination to permit unrestricted use of the site is mandatory in both cases. While actual decommissioning plans and costs will be highly site-specific, generalized costs for the model mill from NUREG-0706 are shown in Table 14.

Table 14. Summary of Cost Estimates for Decommissioning a 2000-Ton-per-Day Uranium Mill

Expenditure	Cost (1980 dollars)
Mill and Building Decontamination:	
12 Man-Years at $30,000 per Man-Year[a]	360,000
Machinery Removal	no cost
Building Removal	no cost
Restoration of Heavily Contaminated Area:	
82,000 Cubic Meters of Dirt Moved at $1.50 per Cubic Meter[b]	120,000
Restoration of Lightly Contaminated Area:	
120 Hectares at $4750 per Hectare[c]	570,000
Subtotal	1,050,000
Engineering, 6 Percent of Subtotal	63,000
Contingency, 15 Percent of Subtotal	157,000
Total	1,270,000

[a]Operator costs to include overhead.

[b]Area involved is 8 hectares.

[c]Depth of excavation is 0.15 meter.

Several mill owners have stated that the cost of decommissioning will greatly exceed the NRC projection. The Kerr-McGee estimate of February 1982 for its 7000-ton-per-day mill at Ambrosia Lake was $1,785,400 in 1981 dollars. This estimate reflects the reclamation requirements currently in effect in New Mexico, an Agreement State, and only the cost of labor and materials.

It should also be noted that some mill owners have stated that the costs cited in this section underestimate the amount of many of the short-term costs.

LONG-TERM COSTS

Long-term costs associated with the management of uranium mill tailings are defined as the surveillance and maintenance costs associated with the tailings pile following cessation of milling operations and permanent stabilization of the pile. Because of the long-lived radionuclides remaining in the tailings, the condition of the pile needs to be monitored for an indefinite period. NRC regulations require that tailings be stabilized in such a manner that at most a "passive monitoring mode" will be adequate to ensure that stabilization efforts remain intact.

The Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978 provides for the transfer of title to any land which is used for the disposal of tailings prior to the termination of a source material license to either the Federal Government or the state in which the tailings are located, at the option of the state. Either the state or the Federal Government is the most likely long-standing human institution to remain viable in the distant future; therefore, it will have to bear responsibility for a long-term monitoring program. The mill tailings act requires individual licensees to bear the cost; and a one-time base charge of $250,000 (1978 dollars), to be levied on mill operators before termination of the license, has been adopted to establish a fund for this purpose. Continued care funds have been established in states which may opt to take title to reclaimed lands. The mill owners must contribute specified amounts to the funds by the time of shutdown. For example, several uranium producers have already paid $1 million into the New Mexico Continued Care Fund.

It is impossible to determine with certainty the future custodial costs for tailings; however, the State of Utah has made estimates for two millsites. The combined annual costs for surveillance and maintenance determined by a state study (Turley, 1980) in Utah were in the range of $72,000 to $160,000 in 1980 dollars for the equivalent tailings from a uranium mill which processed 2000 tons of ore per day for 300 days per year for 20 years (12 million tons of tailings). The study was based on these assumptions:

1. The program is conducted by the Government.
2. The tailings are contained above ground.
3. Surveillance and monitoring are done on a seasonal or periodic basis.
4. Future discount and inflation rates are such that the effective, real discount rates range from 1 to 3 percent.

The costs of surveillance, monitoring, and maintenance as determined in the Utah study are shown in Table 15.

Table 15. Cost Estimate for Annual Surveillance, Monitoring, and Maintenance of Two Stabilized Uranium Tailings Sites

Factor	Cost Estimate (1980 dollars)
Monitoring plus Fencing	22,000
Semiannual Aerial Surveillance of Sites	2,600
Limited Maintenance	34,000
Additional Staff Time	8,000
Radon Measurements	5,400
Total Annual Costs	72,000
If Extensive Maintenance of Vegetation Is Required	+88,000
Total Annual Costs for Two Sites	$160,000

Some companies believe that these costs are greatly exaggerated and are not justified in light of the NRC requirement for "minimum maintenance." (NRC estimated $2500 per year as adequate for passive monitoring of a site.)

BONDING

To assure that necessary financial resources are available to complete mill decommissioning and tailings stabilization upon mill shutdown, the NRC requires a performance surety bond or other appropriate insurance.

Forms, amounts, and costs of surety vary with the individual millsites. The surety agreement for Petrotomics, for example, is for more than $1.9 million. Dawn maintains a $1 million letter of credit for Tailings Area No. 4 alone. Union Carbide at Uravan, Colorado, expects all aspects of its surety plan to come to a total of more than $23 million. The company's Gas Hills mine has a surety agreement in the amount of $3,947,000.

MILL OWNERS' COMMENTS

The uranium industry from 1942 to the late 1960s was virtually controlled as a buyer's monopoly or monopsony, and a large number of the currently operating uranium millsites began operations under the Government-operated monopsony. Cogent arguments have been used over the past few years to influence Federal financial support for the costs to reclaim AEC-related tailings. It is assumed that if tailings stabilization and management requirements had been imposed earlier, mill owners would have been able to pass these costs on to their customer, i.e., the Federal Government.

Title I of UMTRCA set a precedent. The Act directs that a plan be developed for cleaning up defense-related tailings at the inactive sites. Many owners of active millsites deem it unreasonable to expect that the companies involved in uranium mill operations under the former Federal program should now have to absorb the resulting costs associated with tailings waste, especially in the absence of early policy guidelines and regulations related to shutdown and reclamation.

The following is a list of cost items that most mill owners believe should be considered for cost-sharing in a Federal assistance program.

1. Costs for pond stabilization and reclamation, including costs of land acquisition and purchase of earth or other cover.
2. Costs necessary to clean up surrounding off-site lands and structures.
3. Costs for any surface- or ground-water cleanup and protection.
4. Costs for mill decontamination, reclamation, and decommissioning.
5. Costs for land purchases for creation of any necessary buffer zone.
6. Costs of bonding.
7. Costs associated with long-term monitoring and maintenance.
8. Costs of interim reclamation, treatment, and stabilization of the site.
9. Costs incurred by the companies through any judicial award of damages to any individual resulting from radiological and/or nonradiological hazards associated with the site.
10. Administrative costs, including costs of all environmental assessments.

In presenting its estimated costs for stabilization, one company pointed out the following factors which were not included in its proferred estimate of costs but which could prove to be significant:

1. Storm-water runoff diversion.
2. Ground-water or surface-water cleanup.
3. Cleanup of surrounding lands.
4. Land acquisition for buffer.
5. Long-term monitoring and maintenance.
6. Interim stabilization.
7. Judicial awards.
8. Indirect costs such as health physics, environmental control engineering, supervision, administrative overhead, contract fees, and contingencies.
9. Future costs resulting from regulatory changes.

Another company recommended the following specific items as costs to be shared:

1. Costs associated with the transfer of commingled tailings to new impoundments, prior to and following shutdown, including costs associated with the transfer of contaminated soil and reclamation of the old tailings sites.
2. Costs of ground-water and surface-water studies, monitoring, protection measures, and cleanup.
3. Costs of design, engineering, site preparation, and construction of new impoundments to which commingled tailings are transferred.
4. Costs reflecting the time value of money already spent by mill owners for costs attributable to commingled tailings.

COSTS TO BE CONSIDERED FOR SHARING

Many site-specific cost items may have to be negotiated with the owners of the 13 millsites, but this study supports the following costs as they apply to defense-related tailings, as properly includable in cost-sharing approaches that require formulas:

1. All costs of stabilization and reclamation of the tailings at the millsite, including interim stabilization.
2. Costs associated with the transfer of commingled tailings to new impoundments, including costs of land acquisition.
3. Costs of land acquisition for buffer zones and the purchase of suitable cover for the tailings.
4. Costs for surface- and ground-water cleanup, to include necessary studies and protection measures.
5. Costs for decommissioning and decontaminating mills built to supply U_3O_8 in concentrate to the AEC.
6. Costs associated with long-term surveillance, monitoring, and maintenance.

Cost elements that might be considered, but are not clearly appropriate for Government assistance since they are closely related to the general cost of doing business, are as follows:

1. Cost of bonding.
2. Costs reflecting the time value of money already spent by mill operators on commingled tailings.
3. Judicial awards.
4. Administrative overhead.

Unless a flat-fee approach to cost-sharing is adopted, site-by-site engineering appraisals, in light of final regulations, may be necessary to determine an equitable cost breakdown structure for costs to be shared by the Government and the mill owners. Cost elements at each site have different degrees of importance because of the varying characteristics of the 13 millsites. The findings of the engineering studies would establish the exact parameters for individual, negotiated cost-sharing agreements within whichever approach is offered by the Government.

Section VII

COST-SHARING APPROACHES

Any discussion of cost-sharing must be prefaced with the caveat that each active millsite included in this study has unique characteristics. No single cost-sharing approach is likely to be fair and equitable to every owner. Any cost-sharing plan should recognize that the following classes of tailings disposal areas are found at the 13 sites included in this study:

1. All tailings attributable to Government contracts; area no longer in use.
2. Commingled tailings; area no longer in use.
3. Commingled tailings; area to be filled within next several years, then new area used.
4. Commingled tailings; area to be used until mill decommissioning.
5. New area to which one of the above tailings will be moved because the present area is deemed unsuitable for in-place stabilization.
6. New area recently established for commercial tailings disposal.

A summary employing these classes is shown in Table 16.

The existence of these various classes of disposal areas makes it possible for tailings stabilization to be accomplished either on a phased basis during the life of the operation or at mill shutdown and decommissioning. At some mills, stabilization of areas no longer in use could be accomplished any time prior to decommissioning, but might be less costly if done in conjunction with all other reclamation at the end of operations. While this situation contributes to a more efficient reclamation program at the individual millsites, its effect collectively on a program of Government assistance would result in a highly variable payment schedule which would be difficult to control and would extend over an undetermined period of time.

GENERAL APPROACHES

Four <u>general</u> cost-sharing approaches have been considered:

1. Cost-share on the ratio of tonnage of tailings attributable to Government contracts to the total tonnage of tailings impounded at the time of stabilization.

2. Cost-share on the ratio of acreage (area) disturbed or covered with tailings impounded during periods of Government contracts to the total acreage covered at the time of stabilization.

3. Assume that the mill had been shut down at termination of the final Government contract and that the site had been designated for remedial action under the Uranium Mill Tailings Radiation Control Act of 1978 (PL 95-604).

4. Establish, unilaterally or through negotiations, a fee payable by the Government to the mill owner of a specified dollar amount for each:
   a. pound of U_3O_8 produced at the site and sold to the Government, or
   b. ton of tailings at the site attributable to Federal contracts, or

Table 16. Classes of Solid Tailings Disposal Areas

Mill/Location	Inactive		Active Commingled		New (Post-1970)	
	All-AEC A	Commingled B	Nearly Full C	Use Until Shutdown D	Commercial and Old Tails E	Commerical Only F
Cotter, Colo.		Pond 1			Secondary	Main
Union Carbide, Colo.	Sludge Pond		Ponds 1, 2, and 3			Future Production
Anaconda, N. Mex.	Carbonate Pond N Area Acid Pond			Main Pond		
Homestake, N. Mex.	Homestake-New Mexico Partners Pond			Main Pond		
Kerr-McGee, N. Mex.				Ponds 1 and 2		
TVA, S. Dak.	Sand Tailings A and B	East Sand Tailings and Ponds 1-9				
Atlas, Utah				Single Pond		
Dawn, Wash.	Ponds 1 and 2					Ponds 3 and 4
Fed.-Amer. Partners, Wyo.	Pond 1	Pond 2				Future Production
Pathfinder, Wyo.		Pond 2	Pond 1			Pond 2A
Petrotomics, Wyo.			Single Pond			Post-1983 Production
Union Carbide, Wyo.		Above-Grade Pond 1 plus Additions				Below-Grade Pond
Western Nuclear, Wyo.				Single Pond		

c. acre of land at the site covered by tailings impoundments during the Government contracts, or
d. some combination of the above.

Cost-sharing on the basis of tonnage ratios appears reasonable and equitable for tailings stabilization.

The tonnage-based approach has the advantage that the quantities of tailings are, or will be, available to determine the factor or proportion of costs to be shared by the Government. The approach starts with the premise that the tailings attributable to Government contracts can be computed as follows:

$$\frac{\text{Pounds } U_3O_8 \text{ Sold to the Government}}{\text{Total Pounds } U_3O_8 \text{ Produced During Government Contracts}} \times \text{Tons of Tailings in Pile at End of Contracts}$$

Once the tonnage of AEC-related tailings has been established (several adjustments and options are discussed in Section V), the Government share of costs for each pile could be calculated on the ratio of:

$$\frac{\text{Tons AEC-Related Tailings}}{\text{Total Tons of Tailings in the Pile}}$$

Though decisions are required as to which "adjustments" and "options" are to be selected, the ratio should be easily calculated and appears appropriate for sharing stabilization costs, the cost of mill decommissioning, and costs of continued care.

Ratios based on pounds of concentrate have not been considered appropriate for cost-sharing. As the grade of uranium ore has decreased significantly since the end of the AEC purchase program, using the ratio of "pounds U_3O_8 sold to the Government" over the "total U_3O_8 produced over the life of the mill" would result in a disproportionately large amount of tailings being attributed to AEC contracts. Pounds of concentrate purchased by the Government have been taken into account in computing the tonnages of defense-related tailings.

Before an area-based ratio can be calculated, a figure for AEC-related acreage must be determined. Two concepts have been advanced for establishing this acreage. One is to simply use that acreage disturbed or covered by solid tailings at the end of the contract period. Another "area" concept is to prorate this acreage on the basis of the relative amounts of defense and commercial tailings in the pile at the end of the AEC contract period. In either case, an acreage ratio would then be calculated by dividing the resulting AEC-related acreage by the total acreage covered by solid tailings impoundments at the time of stabilization.

Questions have arisen concerning the equitability of acreage ratios employing either of the above concepts. The initial size of a tailings impoundment was sometimes determined by the company's choice to dispose of mill process waters through evaporation, not by the quantity of solid tailings to be impounded. Therefore, larger surface areas were disturbed than may have been necessary had other solution disposal methods been used. Several of the mills have used, and are continuing to use, only one solution/solids disposal area that has been enlarged very little in area since the end of the AEC contract period, but has grown substantially in height. A literal interpretation of "acreage disturbed by AEC-related tailings" would show that the AEC-related tailings account for a high proportion (currently 76 percent) of all areas covered by commingled solid tailings impoundments, though only about 42 percent of these tailings are attributable to AEC uranium purchases. The acreage ratio is expected to decline only slightly as tailings generated in the future are placed in these commingled impoundments, while the tonnage ratio may drop to 25 percent by the time all mills cease operations.

If reclamation had been required at the end of the AEC program, the companies involved would have then incurred the cost of building new and additional impoundments to hold all tailings generated after the end of the AEC contract period. It can be argued that this cost avoidance, which is not reflected in the acreage ratios, should also be shared between Government and industry. Though cost of solid tailings stabilization may be largely area-dependent, the Government share may not be fairly derived through the use of acreage ratios.

The above discussion has centered primarily on the solid tailings impoundments, but the problem of tailings solution ponds also must be addressed. Classes of liquid-only tailings disposal areas are shown in Table 17. These ponds, ordinarily intended for solution evaporation, usually contain tailings-pond decant or other mill solutions, and often are as large as or larger in area than the impoundments for solids. At one location (Edgemont), large ponds were used both to settle the slime portion of the tailings and to dispose of solution through evaporation.

The areas of solution ponds should not be added with areas of solids impoundments, as the costs and methods of reclamation of the areas are not comparable. In some cases, the ponds were created at the discretion of the operator, as alternatives to recycling, subsurface injection of the liquids, or treatment and release of effluents. The largest cost factor regarding reclamation of solution ponds is the potential for ground-water cleanup. While an area-based approach may not be appropriate for sharing solution pond reclamation costs, cleanup of these areas may be considered as a negotiated cost item, or shared on the basis of an appropriate tonnage ratio, calculated for the time when the pond was taken out of service.

Several specific ratios based on tonnage and acreage have been identified as potentially useful in making cost-sharing determinations. The ratios are defined in Table 18. "Basic" and "Modified" ratios can be computed at any point in time in the life of the mill and may have continually changing values as long as the mill continues to operate. Costs would be shared using values of these ratios calculated at specific points in time, such as at the end of AEC contracts, when a pond or pile was taken out of service, or when the mill was decommissioned. Site-specific values for these ratios, calculated from data in this report, are shown in Table 19.

The engineering-assessment approach was considered as an attempt to treat the stabilization of commingled tailings in the same manner as the stabilization of defense-related tailings at the inactive sites under UMTRAP. To use this approach, one would have to assume that the mill ceased operation upon termination of the AEC contract, e.g., December 31, 1970, or some earlier date. It then would be necessary to make an engineering assessment to estimate the decontamination, decommissioning, and tailings stabilization costs for conditions as they existed at that time. The Government contribution would be based on this assessment.

Table 17. Classes of Liquid-Only Tailings Disposal Areas

Mill/Location	Inactive: All-AEC A	Inactive: Commingled B	Inactive: Commercial C	Active Commingled: Nearly Full D	Active Commingled: Use Until Shutdown E	New: Commercial and Old Tails F	New: Commercial Only G
Cotter, Colo.			Ponds 2-10				
Union Carbide, Colo.					Club Ranch Ponds		
Anaconda, N. Mex.							Seven Ponds (1A-3C)
Homestake, N. Mex.							
Kerr-McGee, N. Mex.		Ponds 4, 5, and 6			Ponds 3, 7, and 8		Ponds 9-21
TVA, S. Dak.[a]							
Atlas, Utah		$BaCl_2$ Ponds and Seepage Pond					
Dawn, Wash.							
Fed.-Amer. Partners, Wyo.							
Pathfinder, Wyo.							Ponds 3 and 4
Petrotomics, Wyo.							
Union Carbide, Wyo.							Two Evaporation Ponds
Western Nuclear, Wyo.							

[a]Built solution pond which was never used.

Table 18. Definitions of Ratios

Tonnage Ratios

Basic Tonnage Ratio $= \dfrac{\text{Tons AEC-related tailings}}{\text{Total tons tailings generated}}$

Modified Tonnage Ratio $= \dfrac{\text{Tons AEC-related tailings}}{\text{Total tons tailings generated less tons tailings in commercial-only piles}}$

Contract Tonnage Ratio $= \dfrac{\text{Tons AEC-related tailings less tons removed for backfill during contract period}}{\text{Total tons tailings generated during contract period less tons removed for backfill during contract period}}$

Decommissioning Tonnage Ratio $= \dfrac{\text{Tons AEC-related tailings}}{\text{Total tons tailings impounded at time of mill shutdown}}$

Acreage Ratios[a]

Basic Acreage Ratio $= \dfrac{\text{Acres of surface disturbance directly attributable to AEC-related tailings in solid impoundment areas at end of contract period}}{\text{Total acres disturbed by solid tailings impoundments}}$

Modified Acreage Ratio = Contract Tonnage Ratio X Basic Acreage Ratio or

$$= \dfrac{\text{Tons AEC-related tailings less tons removed for backfill during contract period}}{\text{Total tons tailings generated during contract period less tailings removed for backfill during contract period}} \times \dfrac{\text{Acres of surface disturbance directly attributable to AEC-related tailings in solid impoundment areas at end of contract period}}{\text{Total acres disturbed by solid tailings impoundment areas}}$$

Decommissioning Acreage Ratio $= \dfrac{\text{Acres of surface disturbance directly attributable to AEC-related tailings in solids impoundment areas at end of contract period}}{\text{Total acres disturbed by solid tailings impoundment areas following recontouring}}$

[a]Acreage disturbed by commercial-only impoundments excluded from total acreage figure.

Table 19. Site-Specific Cost-Sharing Ratios (12/31/81)

Cost-Sharing Ratio	Cotter, CO	UCC, CO	Anaconda, NM	Homestake, NM	Kerr-McGee, NM	TVA, SD	Atlas, UT	Dawn, WA	FAP, WY	Pathfinder, WY	Petrotomics, WY	UCC, WY	WNI, WY
Tonnage Ratios													
Basic Tonnage Ratio	0.16	0.58	0.37	0.54	0.33	0.80	0.59	0.40	0.36	0.28	0.13	0.29	0.44
Modified Tonnage Ratio	0.20	0.58	0.37	0.54	0.33	0.80	0.59	1.00	0.36	0.33	0.13	0.32	0.44
Contract Tonnage Ratio	0.98	0.97	0.88	0.91	0.88	0.99	0.93	0.99	0.78	0.76	0.92	0.85	0.94
Decommissioning Tonnage Ratio[a]	-	-	-	-	-	0.80	-	-	-	-	-	-	-
Acreage Ratios													
Basic Acreage Ratio	1.00	1.00	1.00	0.90	0.88	1.00	0.92	1.00	1.00	1.00	0.41	1.00	0.50
Modified Acreage Ratio	0.98	0.97	0.88	0.82	0.77	0.99	0.86	0.99	0.78	0.76	0.35	0.85	0.47
Decommissioning Acreage Ratio[a]	-	-	-	-	-	1.00	-	-	-	-	-	-	-

[a]Computed following final mill closure.

Specific parameters could be agreed upon and actual average unit costs applied at a later date, using UMTRCA cost data. For example, it might be agreed that the tailings pile at a location was of certain dimensions and characteristics at the end of the AEC contract. Then, as UMTRCA cost data become available, those costs would be used to determine the Government share at the active site. This approach, however, presents problems, e.g.: past conditions at a specific point in time are difficult to determine; there is still great uncertainty regarding regulations to be met; and good cost data from UMTRCA may not be forthcoming for many years.

The fee approach is one that would be easy to administer, but might be difficult to set or negotiate in such a way as to be entirely fair and equitable. The simplest approach would be to give the same fee to all mill owners. One possible method for determining this fee would be to use a generic model such as is used in NUREG-0706.

MULTIPLE TONNAGE RATIO APPROACH

Because of the variety of conditions existing at the 13 millsites, there are inherent limitations to the use of any one simple formula. The use of a single ratio approach may not result in an equitable sharing of costs; however, the choice of several ratios appropriately applied to distinct cost elements may present a reasonable approach to cost-sharing. Of those ratios defined in Table 18, two have been selected for use in a reference case.

The two ratios are characterized as follows:

a. Basic Tonnage Ratio. For those costs related to overall activity at the millsite, including mill decommissioning, site decontamination, and long-term surveillance. This ratio is of a general nature and would capture the proportionate share of the costs tied to the generation of defense-related tailings.

b. Modified Tonnage Ratio. To be applied to those cost elements applicable to transfer of AEC-related or commingled tailings to new impoundment areas, physical stabilization and reclamation of the solid commingled tailings piles, and for costs associated with ground-water cleanup. It is assumed that the commercial-only tailings are already in lined impoundments and need not be moved. Because commercial-only impoundments are excluded from this ratio, it better reflects the AEC-related tailings as a proportion of those to be moved.

While these ratios can be determined at any point in time, only those values calculated when commingled piles become inactive and/or mills are decommissioned should be applied in a cost-sharing program. In using the selected ratios for any particular millsite, the Government's contribution would be limited to assistance for those piles, ponds, and areas that contain tailings attributable to Government purchases of uranium primarily for defense programs. In addition, Government assistance for decontamination and cleanup would apply only to situations in which the tailings produced during the period of Government purchases of U_3O_8 contributed to the existing contamination problem. Only mills that processed ore for the production of U_3O_8 purchased by the Government would qualify for assistance in covering the costs of decommissioning.

A reference case which demonstrates the application of two ratios to a breakout of the major cost elements involved in reclamation is displayed in Table 20. The demonstration of the reference case in no way implies that one particular usage of the ratios is the <u>most</u> equitable. However, in recognition of the argument against the use of acreage ratios, only the two tonnage ratios, basic and modified, are applied to the cost elements. The resulting

Table 20. Multiple Tonnage Ratio Approach

Cost Elements[a]	Basic Tonnage[b]	Modified Tonnage[b]
1. In-Place Stabilization of Solid Tailings:		
a. Engineering and Environmental Assessment	x	
b. Purchase and Haulage of Cover Materials; Reclamation of Borrow Area		x
c. Contouring and Cover Placement		x
d. Erosion Control and Revegetation or Rock Cover		x
e. Storm Water Diversion		x
f. Buffer Zone Land Purchase	x	
g. Interim Stabilization		x
h. Reasonable Overhead Charges	x	
2. Movement and Stabilization of Solid Tailings:		
a. Interim Stabilization		
b. Environmental Studies	x	x
c. Creation of New Impoundment		x
(1) Site Selection		
(2) Design Engineering		
(3) Site Preparation		
d. Transport of Tailings		x
(1) Excavation and Loading		
(2) Haulage and Roads		
(3) Dumping and Compaction		
(4) Dust Control		
e. Decontamination of Original Tailings Area (see para. 4)		
f. Stabilization of New Impoundment (see para. 1)		

Table 20. Multiple Tonnage Ratio Approach (continued)

Cost Elements[a]	Basic Tonnage[b]	Modified Tonnage[b]
3. Mill Decommissioning:	x	
a. Dismantling Mill		
b. Removal of Machinery and Buildings		
c. Decontamination of Millsite (see para. 4)		
4. Decontamination:	x	
a. Excavation and Haulage of Contaminated Soil from:		
(1) Millsite		
(2) Windblown Areas		
(3) Evaporation Ponds		
(4) Vacated Tailings Areas		
b. Backfill and Drainage Repair		
c. Revegetation		
5. Ground-Water Cleanup:		x
a. Environmental Assessment		
b. Drilling and Maintenance of Wells		
c. Monitoring System		
d. Chemical Treatment		
e. Pumpback and Storage		
6. Long-Term Surveillance:	x	
a. Annual Inspections		
b. Maintenance and Monitoring		
7. Other:[c]	x	
a. Financial Surety Arrangements		
b. Judicial Awards		
c. Administrative and Legal Overhead		
d. Expenses Arising from New Government Regulations:		
(1) Buttressing Old Dikes		
(2) New Catchment Dams		
(3) Interim Covers, Sprays, etc.		
e. Interest on Capital Expended Prior to Reimbursement		

[a]Only major categories of costs are cited; the breakdown of costs is not exhaustive.

[b]Calculation of total tons is as of a specified time.

[c]Items are not subject to negotiations unless expenses are clearly attributable to AEC-related tailings.

percentages of cost attributable to AEC-related tailings and the Government contributions for the ratios as calculated January 1, 1982, are shown in Table 21.

Table 21. Use of Multiple Ratios (reference case)

Mill/Location	Percentage of Total Costs Attributable to AEC Tailings[a]	Government Contributions Based on NRC Regulations[b] (millions of dollars)
Cotter, Colo.	20	5
UCC, Colo.	58	25
Anaconda, N. Mex.	37	40
Homestake, N. Mex.	54	50
Kerr-McGee, N. Mex.	33	40
TVA, S. Dak.	80	15
Atlas, Utah	59	25
Dawn, Wash.	73	10
FAP, Wyo.	36	10
Pathfinder, Wyo.	31	10
Petrotomics, Wyo.	13	5
UCC, Wyo.	32	10
WNI, Wyo.	44	15
TOTAL	-	260
AVERAGE	44	20

[a]Excludes costs related to commercial-only impoundments.

[b]See Table 3 for total costs at each site; costs rounded to nearest $5 million.

IMPLEMENTATION CONSIDERATIONS

The cost-sharing approaches outlined above have implied differences as to when and how the Government contribution would be payable. Various reasonable schemes for each approach could be devised, and only some of the options are discussed herein.

Cost-Sharing on Ratios of Tons or Acres Disturbed

The implementation of a cost-sharing plan based on either tonnage ratios, area ratios, or some combination, would likely have the following features:

1. The mill owner would maintain responsibility for administering mill decommissioning and final stabilization of all tailings ponds/piles.
2. The Government would reimburse the company the appropriate percentage of allowable costs after company submission of invoices for the work. Performance of work would be subject to Government audit.
3. Most Government contributions would be made following mill decommissioning. Some costs could be billed in advance of decommissioning.

Cost-Sharing Based on Engineering Assessments

The engineering assessments for a detailed reclamation plan for each site as it existed in 1970, or other date, would presumably be commissioned by the Government in cooperation with the individual companies. The former physical characteristics of each site could be established through existing drawings or photographs, or negotiations with the site owners, where records are inadequate.

The costing of the assessment would likely be deferred until the time of decommissioning, when presumably:

1. Reclamation practices and standards would have been established.
2. Current cost information for pile contouring, obtaining and hauling cover materials, and other tasks would be available.

Appropriate cost factors could then be incorporated into the engineering study, and the Government contribution paid to the company on the basis of the completed assessment.

Flat-Rate Payments Approach

The flat-rate payments approach presents a wide variety of options. At one extreme, generic cost model studies by the Government, based perhaps upon experience gained through the UMTRAP, could be used to establish a flat rate (dollars per pound of AEC-purchased U_3O_8, dollars per ton for AEC-related tailings, or dollars per acre disturbed by AEC-related tailings) to be applied to all sites. This would undoubtedly result in some inequities among the recipients; however, had the AEC recognized a future owner liability for tailings at the time of contracting, it likely would have recognized this cost factor and may have paid more under "negotiated" price contracts. It cannot be determined whether or not the AEC would have paid more than $8.00 per pound U_3O_8 during the fixed-price era (post March 31, 1962), even if tailings liability was apparent.

The other extreme could involve detailed site-specific engineering cost estimates, followed by negotiation with each site owner. This approach would then include many of the characteristics of previously discussed methods.

By establishing a flat-fixed rate for reimbursement, two new features are introduced:

1. The company could receive Government contributions prior to actual decommissioning, through tax credits or other means.
2. The Government could more accurately assess the cost of the program under this approach than if one of the other approaches were used.

MILL OWNERS' VIEWS OF COST-SHARING APPROACHES

During the site visits, there were brief discussions of possible cost-sharing options if Federal assistance were to become available. Several mill officials expressed general thoughts on the subject, and the company positions on cost-sharing that were later formulated are included in Appendix E. About one-half of the mill owners reserved comments on cost-sharing during the site visits.

TVA favors an approach to cost-sharing based simply on tonnage of AEC-related tailings compared to total tailings to be stabilized.

Kerr-McGee suggested that a ratio of areas at the end of the contract period to areas at the end of the mill life be used for determination of the equitable share of Government cost for tailings piles and ponds. A ratio of U_3O_8 pounds sold to the AEC to total pounds sold at the end of the mill life could be used to determine the Government's share of the cost for mill decommissioning. Atlas Corporation also favors an area-based option.

Homestake recommended a combination of the two factors: ratio of areas for stabilization costs and a ratio of tons or pounds (AEC-related/commercial) for other costs.

Cotter Corporation indicated that the Government should share in specific items of cost, with the portion decided by a formula for each item. Cotter's recommendation is basically a tonnage approach, with flexibility for modification where site-specific circumstances warrant a different approach.

Federal-American favors an option in which active mills are assumed to have shut down at the end of the AEC purchase period, with the cost of stabilizing AEC-related tailings computed on a proportional basis.

Petrotomics indicated that Federal assistance should be in the form of R&D programs to seek the solution to problems encountered in the disposal of tailings below grade rather than cost-sharing.

Dawn suggests that the Government have 100 percent responsibility for stabilization of those piles which contain only AEC-related tailings, and assign to the operator 100 percent responsibility for piles which contain only commercial production tailings. This view is intended to apply essentially to stabilization; the company recognizes that many of the smaller cost components (e.g., monitoring, mill decommissioning, and maintenance) do not fit the separate area approach, even for Dawn. Dawn suggested that some production-related basis would be more appropriate for such costs, and stated a preference for the formula:

$$\text{Government Share} = \frac{\text{Pounds } U_3O_8 \text{ Produced for AEC Contract}}{\text{Total Pounds } U_3O_8 \text{ Produced}}$$

Section VIII

ORDER-OF-MAGNITUDE COST ESTIMATES

REGULATORY CONSIDERATIONS*

The United States is currently in a transition phase since the traditional regulatory structure under the Atomic Energy Act (AEA) for dealing with uranium mill tailings is being modified to implement amendments to the act made by the UMTRCA of 1978.

Prior to enactment of the UMTRCA, the regulatory authority of the NRC (formerly the Atomic Energy Commission) over uranium mill wastes was an incident of its authority under 42 U.S.C. §§2092 to license the receipt or transfer of source material.

The NRC's authority over source material does not extend to raw ore. However, once the mined ore begins to be processed, it becomes source material and a license is required for such processing. The license is issued by the NRC. If the processing occurs in a state which has entered into an agreement with the NRC whereby it has been delegated the latter's source material regulatory authority, the license is issued by that Agreement State.

The basic regulatory mechanism for controlling mill tailings has been through the imposition of conditions in such licenses. Although there was often an absence of effective waste management conditions in milling licenses in the early years of uranium milling in the United States, uranium milling licenses issued in recent years by both the NRC and Agreement States often have contained detailed requirements concerning the disposal of mill tailings. Such tailings are not source material since they typically contain less than 0.05 percent uranium and thorium; but the accepted theory has been that they can be regulated as an incident of the process for which a source material license is required, at least as long as the underlying source material license remains in effect.

The UMTRCA changed the regulatory authority over mill tailings by adding to the AEA definition of byproduct material (theretofore defined in a manner irrelevant for present purposes) to include "the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content," 42 U.S.C. §2014 (e)(2), and by further amending the AEA to create express regulatory authority over this newly defined byproduct material.

The UMTRCA expanded EPA and NRC regulatory authority over tailings. The EPA is to promulgate "standards of general application for the protection of the public health, safety, and the environment from radiological and nonradiological hazards associated with the processing and with the possession ... and disposal of the newly defined byproduct material at active uranium mills and at tailings disposal sites." [§2022 (b)(1)]. These EPA standards are to be enforced by the NRC in its licensing program and by the Agreement States.

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*From "Legal-Institutional Framework and Environmental Requirements Applicable to Uranium Mine and Mill Wastes in the United States," James R. Bieke and David B. Cook, May 1980.

In short, the AEA, as amended by the UMTRCA, provides for detailed EPA standards and NRC regulations focussed expressly on uranium mill tailings control (standards which will be given force to a significant degree in Agreement States) and provides for eventual Government ownership and management of tailings disposal sites.

The NRC has promulgated significant new regulations pursuant to its regulatory authority under the AEA as amended by the UMTRCA (45 Federal Register 65521, October 3, 1980). The NRC has been barred from enforcing these regulations by PL 97-88, the Energy and Water Development Appropriations Act, until October 1, 1982. The consensus among industry and Government is that new regulations, based on less stringent standards, will be proposed, possibly before the publication of this report. However, the present EPA standards and NRC regulations are used herein for cost-estimating purposes to provide an upper benchmark for potential stabilization costs.

The State of New Mexico, which is currently an Agreement State, has promulgated its own regulations in response to UMTRCA. The State of New Mexico and resident mill owners regard these regulations as more practicable than the corresponding NRC regulations and adequate to protect health and the environment. Differences are listed in Table 22.

Table 22. Major Differences Between NRC and New Mexico Regulations

NRC Regulations	New Mexico Regulations
Below-grade disposal of tailings is "Prime Option."	Below-grade disposal is "one option."
Maximum possible flood for alternate site evaluation.	Regulations provide for site evaluation of 100-year flood event; State Engineer requires analysis of effects of probable maximum flood.
No degradation of ground water.	Comply with New Mexico regulations of Water Quality Control Commission.
Stabilization of tailings disposal design without active maintenance to preserve stability for thousands of years.	Requirements provide for stabilization to last 200 years.
Radon flux limit of 2 $pC/M^2/sec$ imposed.	Radon/radon daughter concentration limit of 1/30 Working Level imposed at boundary of area.
Surety arrangements prohibit self-insurance.	Permit self-insurance under controls.
EPA 25-millirem rule for uranium mills.	Excludes tailings piles as a source of radiation under 25-millirem rule; does require engineering controls to reduce tailings emissions.

ASSUMPTIONS FOR COST ESTIMATES

One method of making a first order-of-magnitude estimate of the stabilization costs can be based on NUREG-0706, dated September 1980. A more precise evaluation will require detailed engineering studies related to the site-specific nature of the factors affecting actual costs of stabilization at the 13 millsites under review.

The costs discussed are in 1980 dollars with no escalation or discounting factors used for expenditures occurring over a project's lifetime. Lifetime costs are taken as the sum of capital costs plus annual or periodic operating costs summed over the operating time period of a model mill (15 years).

In its coverage of tailings management programs, NRC describes a model tailings pile and a base case and nine alternatives for management of tailings, progressively more demanding and more costly (see Table 23). The model mill is assumed to generate 2000 tons per day of dry tailings slurried in water to about 50 percent solids by weight which are sent to a tailings retention system. The tailings pond is initially a square basin formed by low earthen embankments which are compacted on the outer side to provide strength. Final embankments would be 33 feet high, 43 feet broad at the crest, 174 feet at the base, and 3100 feet long at the center line. Volume of the final embankments would be 1,630,000 yd^3. Total tailings disposal area is around 250 acres, of which 200 acres contain tailings. The ultimate depth of the tailings pile is calculated to be about 26 feet. (A more detailed description of the tailings ponds is presented in Appendix B of NUREG-0706.)

The base case and Alternative 1 cited in Table 23 are not considered adequate to meet the requirements of long-term stabilization. As specified in NUREG-0706, Alternative 1 is unacceptable because of possible associated ground-water contamination and the need for ongoing active maintenance after reclamation. The NRC staff noted that Alternatives 7, 8, and 9 are unproven and probably not cost effective; the NRC staff does not consider implementation of those alternatives necessary to achieve the fundamental objectives of long-term tailings disposal. Alternatives 2 through 6, therefore, are the most probable courses of action for stabilization. In this regard, it should be noted that a great number of potential systems are possible by slightly modifying and using a combination of GEIS alternatives or by modifying an alternative in a staged fashion.

In NUREG-0706, comparative lifetime costs were presented for each alternative, with a range of costs from $900,000 to $200,000,000. The lowest cost is associated with the base case, and the largest is for burial of tailings in a mine after fixation with asphalt.

Table 23. Description of NRC Alternative Stabilization Methods[a]

Alternative No.	Description	Cost (dollars) per Short Ton of Tailings
1	Tailings slurry to above-ground impoundment; compaction of bottom.	0.95
2	Below-grade burial in open-pit mine; tailings in slurry form; bottom and sides lined.	1.32
3	Below-grade burial in open-pit mine; tailings dewatered and bottom lined.	2.04
4	Below-grade burial in specially excavated pit; impermeable subsoil assumed.	1.80
5	Below-grade burial in specially excavated pit; lined sides and bottom.	2.28
6	Above-grade burial in naturally occurring basin; siting and design features assure long-term stability.	1.41
7	Fixation in cement or asphalt; burial in open-pit mine.	21.40
8	Fixation in cement or asphalt; burial in deep mine.	21.60
9	Nitric acid leaching; more complete removal of radioactivity; lined and dammed natural basin.	10.12

[a]Source: NUREG-0706, September 1980.

In this study, probability estimates were placed around the alternatives and their costs. The estimates are subjective and are used here only for a first-order estimate of the total cost of stabilization that might be associated with potential Federal assistance for the 13 active millsites.

In the following table, the cost per ton of tailings for stabilization is treated as a random variable. The mean of the random variable is the sum of the values of the random variable weighted by the probability that the random variable will take on a certain value, in this case the cost per ton of tailings stabilized for one of the alternatives outlined by the NRC staff. Table 24 indicates that the expected value, the cost for a generic case, is $1.90 per short ton. This cost factor is used below to determine ranges of the total potential cost of Federal assistance.

Table 24. Stabilization Costs (1980 dollars)

NRC Alternatives	Estimated (dollars/short ton)	Subjective Probability	Value of Alternative
1	0.95	0.000	$0.00
2	1.32	0.077	0.10
3	2.04	0.153	0.31
4	1.80	0.230	0.42
5	2.28	0.307	0.70
6	1.41	0.230	0.32
7	21.40	0.001	0.02
8	21.60	0.001	0.02
9	10.12	0.001	0.01
Expected Value		1.000	$1.90

NRC did not use in its cost bases all capital and operating costs that could be considered. For example, mill owners' costs for engineering were not included among the capital cost elements, and taxes on land and facilities were not included in operating costs. Such cost items, if taken into consideration, would add approximately 30 percent or more to the costs quoted above. In addition, costs given in NUREG-0706 are of the engineering type, estimated to be accurate within about ± 25 percent. Furthermore, no contingency costs were included. It seems warranted, therefore, to increase the $1.90-per-ton value in Table 24 by 30 percent for engineering design and construction management, by 25 percent for contingencies, and another 25 percent because of the nature of the estimates. Therefore, the expected value to use for comparative study is $3.86 per short ton.

RANGES OF POTENTIAL COST

An approximation of potential costs can be obtained by using the alternatives described in NUREG-0706, their costs, and the calculation of an "expected value" of $3.86 per short ton of tailings to be stabilized. Table 25 lists the stabilization costs for the 13 active mills in this review, calculated by using the expected-value approach for the tonnage existing at end-1981.

Table 25. Stabilization Costs (Based on NUREG-0706)

Mill/Site	Tailings at Site (millions of tons) AEC	Commercial	Total	Estimated Costs (millions of dollars) AEC	Commercial	Total
Cotter/Colo.	0.3	1.6	1.9	1.2	6.2	7.4
Union Carbide/Colo.	5.7	4.2	9.9	22.0	16.2	38.2
Anaconda/N. Mex.	8.8	14.8	23.6	34.0	57.1	91.1
Homestake/N. Mex.	11.4	9.8	21.2	44.0	37.8	81.8
Kerr-McGee/N. Mex.	10.0	20.4	30.4	38.6	78.7	117.3
TVA/S. Dak.	1.6	0.4	2.0	6.2	1.5	7.7
Atlas/Utah	6.0	4.2	10.2	23.2	16.2	39.4
Dawn/Wash.	1.2	1.8	3.0	4.6	7.0	11.6
Fed.-Amer. Partners/Wyo.	2.1	3.8	5.9	8.1	14.7	22.8
Pathfinder/Wyo.	2.7	6.8	9.5	10.4	26.3	36.7
Petrotomics/Wyo.	0.7	4.8	5.5	2.7	18.5	21.2
Union Carbide/Wyo.	2.1	5.2	7.3	8.1	20.1	28.2
Western Nuclear/Wyo.	3.4	4.3	7.7	13.1	16.6	29.7
Totals	56.0	82.1[a]	138.1[a]	216.2	316.9	533.1

[a]Includes 4.3 million tons of tailings in commercial-only piles for which the costs of stabilization will not be shared by the Government.

If there currently are approximately 138 million tons of tailings to be stabilized at the 13 active mills (depending on the varying dates of closing down), this translates into a total cost of approximately $533 million. Since there are 56 million tons of AEC-related tailings, the potential cost of Federal assistance would be on the order of $216 million for tailings stabilization alone.

MILL OWNERS' COST ESTIMATES

The owners' estimates of stabilization costs and decommissioning vary according to their perception of current and future state and Federal regulations. If favorable assumptions are made about application of NRC regulations, Kerr-McGee estimates that the direct costs of reclamation based on stabilization in place and decommissioning would be $19.2 million (1981 dollars). If the company is required to move all future-generated tailings, the cost could approach $100 million at the close of operations scheduled for 1998. Costs may be considerably higher if existing tails must be moved. For comparison, the company estimates that direct costs of stabilization in place under Environmental Improvement Board (EIB) regulations would be $12.5 million; this excludes a number of indirect costs.

Petrotomics at Shirley Basin has a surety agreement in the amount of $1,928,860 (1981 dollars); the bond is held by the State of Wyoming. The company has a basic tailings stabilization plan that includes capping with

6.5 feet of clay, 0.5 foot of topsoil, and fertilization and revegetation. This end-of-operation project may cost $1 million. However, at the end of another 2 years when the present impoundment is full and given more stringent regulation, e.g., contours at 10:1 or 5:1 slopes, stabilization could cost $10 to $15 million.

Reclamation plans and estimates from other mill owners are detailed under "Discussion of Viable Stabilization Options" in each of the site reports (see Appendix A).

From the mill owners' comments on estimated costs of stabilization and decommissioning, although not always complete, one can produce the following range of total costs: $280 to $524 million (see Table 26). It should be noted, however, that this is a very rough approximation since not all costs are in current dollars, not all cover the same cost factors, and not all are based on engineering studies nor like assumptions regarding regulatory requirements.

Table 26. Mill Owners' Estimates of Costs[a] (millions of dollars)

Mill/Location	Stabilization Range	Decommissioning Range
Cotter/Colo.	10.0-20.0	-
Union Carbide/Colo.	10.2-13.6	-
Anaconda/N. Mex.	60.0	-
Homestake/N. Mex.	60.0-120.0	-
Kerr-McGee/N. Mex.	40.0-100.0+	1.8+
TVA/S. Dak.[b]	10.8-35.0	1.8
Atlas/Utah	3.3-72.0	2.3
Dawn/Wash.[b]	3.6	1.3
Fed.-Amer. Partners/Wyo.	20.0-30.0	-
Pathfinder/Wyo.	5.0-7.0	-
Petrotomics/Wyo.	10.0-15.0	-
Union Carbide/Wyo.	8.4-9.4	-
Western Nuclear/Wyo.	13.8	1.9
Estimated Totals for 13 Sites	255.1-499.4	24.0[c]

[a]Estimates are based on varying cost factors discussed in the site reports.

[b]Decommissioning cost estimated as a portion of total cost provided by company.

[c]Average for five mills applied to thirteen sites.

The AEC-related tons of tailings (56 million) represented 41 percent of the total tailings as of end-1981, and, at that time, a program such as the one being considered would have suggested the need for Federal assistance of $115 to $215 million in 1980 dollars.

In summary, cost may be a factor to consider in making a decision on providing Federal assistance for stabilization and management of the defense-related uranium tailings. Unfortunately, detailed costs of stabilization of the tailings at all the 13 active sites with commingled tailings are not available. Most mill owners provided rough estimates of the costs of stabilization and/or decommissioning; however, others stated that there are too many uncertainties to allow a good estimate to be made at this time.

ADDITIONAL ESTIMATES

In 1980, the NRC developed preliminary estimates of costs of tailings management for a model mill, and EPA published unit costs and estimates of costs for several modes of stabilization at 21 inactive uranium mill tailings sites. In NUREG-0706, the estimated total cost was provided for the alternative disposal modes it examined, e.g., the total costs for the open-pit disposal alternative ranges from about $11.3 to $13.2 million (2000 short tons per day, model mill operating 15 years and generating 9.3 million tons of tailings). The approximate lifetime cost for tailings management in the passive monitoring mode with below-grade disposal and requiring special excavation is in the range of $16.6 to $21.1 million ($1.79 to $2.27 per ton). Excavation costs result in an increase in total costs beyond those experienced for open-pit disposal. As noted earlier, these estimates do not consider all cost elements, e.g., contingency costs could be as much as 25 percent of quoted costs. The EPA estimated that the costs of the probable disposal option, cover to control radon, for its "average" tailings pile ranged from $1.30 to $6.60 per ton of tailings, in 1980 dollars. The range of costs is due to the different types of remedial action that can be taken to stabilize a particular site.

Assuming, however, that the average cost to the 13 mill owners will be akin to the $21.1 million or $2.27 per ton estimated for model-mill tailings placed below grade in a special excavation, estimates of stabilization costs for each can be calculated as presented in Table 27.

Table 27. Estimates of Stabilization Costs (Below Grade; Special Excavation)

Mill/Location	Total Tailings, End-1981 (millions of short tons)	Costs at $2.27/Ton (millions of dollars)
Cotter/Colo.	1.9	4.3
Union Carbide/Colo.	9.9	22.5
Anaconda/N. Mex.	23.6	53.6
Homestake/N. Mex.	21.2	48.1
Kerr-McGee/N. Mex.	30.4	69.0
TVA/S. Dak.	2.0	4.5
Atlas/Utah	10.2	23.1
Dawn/Wash.	3.0	6.8
Fed.-Amer. Partners/Wyo.	5.9	13.4
Pathfinder/Wyo.	9.5	21.6
Petrotomics/Wyo.	5.5	12.5
Union Carbide/Wyo.	7.3	16.6
Western Nuclear/Wyo.	7.7	17.5
Totals	138.1	313.5

Applying the NRC range of costs to the 13 active mills in the manner discussed above and displayed in Table 27, the cost of a stabilization, to include decommissioning ($17 million), would be approximately $330 million. If the cost of $2.27 per ton used in Table 27 were modified to include a factor of 30 percent for engineering design and construction management plus a 25-percent factor for contingencies, an estimate of the total cost for a program to stabilize approximately 138 million tons of tailings could reach $670 million, to include decommissioning. If departures from current technology are considered, e.g., burial of the tailings in a mine after combining the tailings with asphalt, the costs could reach $2.8 billion!

Assuming that the portion of tailings generated under Federal contracts is about 41 percent (the percentage of Federal tailings to all of the tailings that have been produced at the mills as of end-1981), the cost of cleaning up only the on-site tailings that were generated under Federal contracts, using current technology, could cost $275 million (in 1980 dollars) including decommissioning. The costs do not include any remedial action off-site in vicinity properties.

In 1981, Ford, Bacon & Davis Utah, Inc. (FBDU) prepared updated engineering assessments of stabilizing the tailings at inactive uranium millsites for DOE under UMTRAP. These reports contain estimated costs for stabilization of the tailings in their present locations, with the addition of 3 meters of stabilization cover material. Of the studies available at GJAO, there are six for inactive sites with more than 1 million tons of tailings each. The reported tonnages of tailings and other contaminated materials on-site were reviewed, as well as the number of acres related to tailings and total on-site materials (see Table 28). Using the estimated costs for cleanup of contaminated materials at these six inactive sites, average costs per ton and per acre were calculated (see Tables 29 and 30). The FBDU assessments contain cost estimates to include a 30-percent factor for engineering design and construction management plus a contingency factor.

In Table 29, the total on-site cost is distributed over the tonnage of contaminated materials to include tailings. The FBDU assessments costed the work to stabilize all the contaminated materials on-site, and separately off-site. Estimated costs for stabilizing AEC-related tailings (56 million tons) would range from $188 million based on tonnage to $225 million based on acreage. These figures are close to the $215 million suggested by the review of mill owners' rough estimates.

Table 28. Selected Inactive Uranium Mill Tailings Sites (sites with more than 1 million tons)

Millsite	Tailings On-Site (millions of short tons)	Tailings Piles (acres)	Material On-Site[a] (millions of short tons)	Materials On-Site (acres)	Tailings Off-Site (short tons)	Materials Off-Site (acres)
Monument Valley, Ariz.	1.1	32	1.4	86	14,000	13
Shiprock, N. Mex.	1.7	72	3.2	88	1,000	N/A
Grand Junction, Colo.	1.9	61	3.2	68	N/A	N/A
Rifle (Old and New), Colo.	3.1	45	3.7	128	N/A	N/A
Salt Lake City (Vitro), Utah	2.6	111	3.1	128[b]	333,000	198[c]
Durango, Colo.	1.6	21	2.1	38	18,000	N/A

[a]Tailings and other contaminated materials stabilized on-site under UMTRCA.

[b]Total acres of site.

[c]Does not include all off-site locations.

SOURCE: 1981 FBDU engineering assessments prepared for DOE.

Table 29. Estimated Cost of Stabilizing Materials at Inactive Millsites[a] (Off-Site Remedial Actions Excluded)

Millsite	Cleanup of Contaminated Materials	
	Dollars/Short Ton	Dollars/Acre
Monument Valley, Ariz.	3.03	49,129
Shiprock, N. Mex.	3.75	136,648
Grand Junction, Colo.	2.89	136,214
Rifle (Old and New), Colo.	2.55	73,634
Salt Lake City (Vitro), Utah	4.24	102,831
Durango, Colo.	3.64	175,329
Averages	$3.35	$112,298

[a]Cost includes estimates for engineering design and construction management (30 percent of base cost) plus 25 percent contingency, in 1980 dollars.

SOURCE: Calculations based on data in 1981 FBDU engineering assessments prepared for DOE.

In Table 30, the same total cost is distributed only over the tonnage of tailings at each site, which relates values to those used in other sections of this study. Estimated costs for stabilizing AEC-related tailings would, on this basis, range from $268 million based on tonnage to $381 million based on acreage.

Table 30. Estimated Cost of Stabilizing Tailings at Inactive Millsites[a] (Excludes Other On-Site and Off-Site Materials)

Millsite	Dollars/Short Ton	Dollars/Acre
Monument Valley, Ariz.	3.84	132,031
Shiprock, N. Mex.	7.08	167,014
Grand Junction, Colo.	4.88	151,844
Rifle (Old and New), Colo.	3.04	109,445
Salt Lake City (Vitro), Utah	5.08	118,581
Durango, Colo.	4.78	363,691
Averages	$4.78	$190,434

[a]Cost includes estimates for engineering design and construction management (30 percent of base cost) plus 25 percent contingency, in 1980 dollars.

SOURCE: Calculations based on data in 1981 FBDU engineering assessments prepared for DOE.

If the latest engineering assessments for inactive millsites under UMTRCA are used to project potential costs for the purposes of this study, a reasonable first-order estimate for stabilizing defense-related tailings at the 13 active millsites in their present locations would range from $225 million to $381 million.

SUMMARY OF COST ESTIMATES

Table 31 is a summary of the estimates for Government contribution toward the stabilization of commingled tailings at the 13 active millsites, as discussed in this section. If NRC regulations were modified to become more like those adopted in some Agreement States, the Government contribution could range from $100 million to $175 million, rather than the $215 to $381 million derived in this section.

Table 31. Summary of Estimates[a]

Basis of Estimate	Cost (millions of dollars)
Mill Owners' Rough Estimates	215
NRC "Expected Value"	216
FBDU Tonnage Estimate	268
NRC "Below Grade"	275
FBDU Acreage Estimate	381

[a]These estimates do not include cleanup of solution storage ponds, surface- or ground-water decontamination, or all mill decommissioning costs.

The General Accounting Office (GAO), in its report of February 5, 1979, stated that the cost of cleaning up all of the tailings at selected active millsites was highly uncertain, that the total cost could range from $4 million to $315 million using current technology. The GAO pointed out that the proportionate cost of cleaning up only the tailings that were generated under Federal contract could range from about $2 million to $129 million, with costs varying for each mill depending on the type of remedial action taken. Updating these costs to 1980 dollars, the GAO estimate would now show that the proportionate cost for AEC-related tailings stabilization could approach $175 million. The GAO estimate is lower than the others, probably because it does not reflect the stringent, currently suspended NRC regulations.

Section IX

GLOSSARY

As used in this report and in the individual site reports, these terms have the following definitions.

Commingled Tailings: Defense-related tailings that have been covered, mixed, or impounded with tailings that resulted from processing uranium ores for the production of U_3O_8 for sale to commercial buyers.

Defense-Related Tailings: The solid wastes or tailings that resulted from the processing of uranium ores for the production of U_3O_8 in concentrate for sale to the AEC or its predecessor, the Manhattan Engineer District. Synonymous with this term are the terms "AEC-related" and "tailings attributable to AEC contracts."

Decommissioning: The actions taken after mill shutdown to dismantle and/or decontaminate the mill and related facilities.

Decontamination: The removal or cleanup of radiological and chemical contaminants resulting from the milling process to standards prescribed by the EPA, NRC, and state agencies. Usually decontamination involves cleanup of milling equipment, buildings, and open lands, and may include restoration of surface- and ground-water quality if degradation has occurred.

Interim Stabilization: Actions taken during mill operation to correct an undesirable condition of the tailings impoundment, usually to satisfy regulatory requirements.

Reclamation: The overall final efforts by the millsite owner that are directed toward site cleanup for possible release or disposal in accordance with regulations.

Residual Radioactive Material: (1) Tailings which result from processing uranium-bearing ores; and (2) other radioactive wastes at a processing site which relate to ore processing, including any residual stock of unprocessed ores or low-grade materials.

Site: All real property directly associated with the uranium milling process, including but not limited to, the mill proper, ore stockpile areas, tailings impoundments, and liquid or solution waste storage and evaporation ponds.

Source Material: Uranium or thorium ores which contain by weight one-twentieth of 1 percent (or more) of uranium, thorium, or any combination thereof.

Stabilization: Actions taken to consolidate the tailings and contaminated soils, and to place them in a condition which requires minimum control and maintenance for the long term.

Stabilized Tailings Management: Long-term site surveillance and control to assure the integrity of the stabilized tailings and to provide for any required monitoring and/or maintenance.

Tailings: The remaining portion of a metal-bearing ore after some or all of such metal, such as uranium, has been extracted. Tailings sometimes are separated into a coarse fraction called sands and a fine fraction known as slimes. All tables in this report refer to dry solids, but it is recognized that a broader definition includes tailings solutions.

Uranium Mill: An ore processing plant consisting of machinery, equipment, and buildings where uranium-bearing ores are treated by physical and chemical processes to extract and recover the uranium in the form of a dried concentrate containing about 85 percent U_3O_8.

Vicinity Property: Any real property or improvement thereon outside the legal boundary of the site that is determined to be contaminated with tailings or other residual radioactive material derived from the millsite.

Section X

ACRONYMS

AEA	Atomic Energy Act
AEC	Atomic Energy Commission
AMC	American Mining Congress
BPNL	Battelle Pacific Northwest Laboratories
CFR	Code of Federal Regulations
DEIS	Draft Environmental Impact Statement
DOE	Department of Energy
EIB	Environmental Improvement Board (New Mexico)
EID	Environmental Improvement Division (New Mexico)
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
FAP	Federal-American Partners
FBDU	Ford, Bacon & Davis Utah, Inc.
FEIS	Final Environmental Impact Statement
GAO	General Accounting Office
GJAO	Grand Junction Area Office
GEIS	Generic Environmental Impact Statement
LPI	Lucius Pitkin, Inc.
MED	Manhattan Engineer District
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
TVA	Tennessee Valley Authority
UCC	Union Carbide Corporation
UMTRAP	Uranium Mill Tailings Remedial Action Program
UMTRCA	Uranium Mill Tailings Radiation Control Act
USC	United States Code
WNI	Western Nuclear, Inc.

Section XI

REFERENCES

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APPENDIX A: SITE REPORTS

SITE REPORT: COTTER CORPORATION
Canon City, Colorado

INTRODUCTION

The Cotter Corporation operated a small alkaline-leach uranium ore-processing plant, or mill, near Canon City, Colorado, during the period 1958-1965 to produce uranium for sale to the Federal Government for use primarily in defense programs. The mill resumed operation late in 1966 for sale of uranium in the commercial market. During 1967-1968, the mill was enlarged, and an acid circuit was added. Thus, tailings from the earlier operation were covered by and commingled with tailings from the later operation.

Cotter's situation is somewhat unique in that it has an old mill that was shut down in December 1979, thereby ending the commingling of tailings. A larger new mill commenced operation in September 1979, with all its tailings being impounded in a separate clay and membrane-lined area. In April 1981, Cotter began moving all the commingled tailings to a segregated area within the impoundment built for the new mill.

BACKGROUND AND HISTORY

OWNERSHIP

The uranium mills and tailings impoundments are located on a section of land (640 acres) owned by Cotter Corporation. Cotter acquired the property in 1957 for the construction of a pilot plant to develop processes for the treatment of Colorado Front Range uranium ores. In 1974, Cotter became a wholly owned subsidiary of Commonwealth Edison, Inc., Chicago, Illinois.

The initial source materials license for ore processing at the Canon City mill was issued by the AEC in 1958. In 1968, Colorado became an Agreement State and assumed regulatory and licensing authority over uranium mills in the state. The Colorado Department of Health (CDH), in August 1979, issued an amendment to the Cotter Corporation Canon City mill license for operation of the new mill, but without an expiration date. Cotter is expecting CDH to issue a renewal in the near future with a term of 5 years, making the license expire in August 1984.

PRODUCTION HISTORY

The initial AEC contract was signed with Cotter Corporation on May 23, 1957, to purchase U_3O_8 concentrate from a 50-to-75-ton-per-day pilot plant at Canon City. The purpose of the pilot plant was to develop processes for the treatment of Colorado Front Range ores that previously had been shipped great distances for milling. The plant was constructed and commenced operation in 1958, the first concentrate being delivered to the AEC in August of that year.

On December 17, 1959, the AEC contract was extended to March 1, 1960, and the pilot plant was enlarged to a full-scale mill with a capacity of 150 to 220 tons of ore per day. Additional AEC contracts were executed for the purchase of U_3O_8 through February 1965. With expiration of the AEC contracts, the last ore was fed on January 15, 1965, and the mill shut down in February.

During the period 1958-1965, Cotter processed 319,400 tons of ore averaging 0.53 percent U_3O_8. The AEC purchased 3,142,988 pounds U_3O_8 at an average price per pound of $8.23 under AEC Contract Nos. AT(05-1)-735 and -783. The distribution between AEC contracts was as follows:

Contract No.	Period (FY)	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-735	1959-1960	501,298	$8.00
AT(05-1)-783	1960-1965	2,641,690	8.27
Total	1958-1965	3,142,988[a]	$8.23

[a]Cotter mill records indicate that 3,157,036 pounds were delivered to the AEC.

Cotter purchased 92.5 percent of the ore fed to process, 23 percent of which was AEC ore acquired in the Shirley Basin area of Wyoming and sold to Cotter. The AEC exercised its contractual rights to substitute ore for shortfalls in deliveries of ore from other producers that had been assured a market at the Cotter mill. Cotter would have preferred to substitute Colorado ores but was required to take the AEC ore from Wyoming. The recovery of U_3O_8 from all ores averaged 93.5 percent, indicating an average residual U_3O_8 content in the tailings of 0.035 percent. Only uranium was recovered, no other products, and all sales were to the AEC, none in the commercial market.

In 1967, the mill was modified and enlarged to process about 400 tons per day in the alkaline-leach circuit and 100 tons per day in an acid leach-solvent extraction circuit. The unique acid circuit was designed to handle residues from the processing of high-grade ores from the Belgian Congo region during World War II by Mallinckrodt Chemical Works in St. Louis, Missouri. These residues were the property of the AEC and had been sold on a competitive bid basis, about 1965, to a firm that had planned to process them, but, after moving them to another location, went bankrupt. Cotter acquired the residues (about 75,000 tons), moved them to Canon City, and recovered residual uranium, copper, nickel, and cobalt. Also from the "Congo raffinates" (residues), Cotter recovered during 1971 a "sludge" high in protactinium-231 and ionium-230 under a contract with the AEC's Mound Facility (Ohio). Some 1250 drums of sludge were shipped to Mound. Cotter was given U_3O_8 in concentrate by the AEC (Grand Junction) for the U_3O_8 contained in the sludge, about 60,000 pounds.

After the mill resumed operating late in 1966, for sale of uranium in the commercial market, it operated until December 7, 1979, the last day tailings were commingled. A new 1500-ton-per-day acid leach uranium-vanadium mill was constructed for a 20-year life and started operation in September 1979. An entirely new clay and Hypalon-lined impoundment area was constructed to received tailings from the new mill.

Cotter is continuing to operate with all of its production dedicated to its parent, Commonwealth Edison. Its principal ore supply, the Schwartzwalder Mine near Golden, Colorado, was acquired by Cotter in 1966. Additional ore supplies were assured when Cotter was the successful bidder in 1974 on 14 DOE mining lease tracts in the Uravan Mineral Belt of Western Colorado.

PROCESS DESCRIPTIONS AND MAJOR CHANGES

The flow sheet of the 50-to-75-ton-per-day pilot plant initially constructed at Canon City consisted of crushing, fine grinding, alkaline leach with hot sodium carbonate-bicarbonate solution, filtration to separate the solids (tailings), solution clarification, and precipitation of the uranium with caustic soda (sodium hydroxide). This same basic flow sheet was used as the plant was expanded during the life of the AEC contracts (1958-1965).

With the plant expansion in 1967, a flotation circuit was added to remove the iron and copper sulfides from the ore prior to alkaline leaching. These sulfides were acid leached to remove the uranium before shipment to the smelter. The alkaline or carbonate circuit had a nominal capacity of about 400 tons of ore per day from 1968 until shutdown in December 1979.

The acid leach-solvent extraction circuit, constructed in 1967, was designed to handle the uranium-bearing residues from St. Louis, as previously described. The acid circuit was unique in that it provided for the extraction and recovery of uranium, copper, nickel, and cobalt. In 1969, it was reported that the residues being fed to process averaged 0.28 percent U_3O_8, 1.00 percent copper, 1.5 to 2.0 percent cobalt, 2.0 percent nickel, and 0.2 percent selenium. The recovery of protactinium and ionium (previously described) required development of special process technology. Processing of these residues was completed in 1971. Subsequently the acid circuit was used to process uranium ores unamenable to alkaline leaching and other materials, such as spent catalysts for molybdenum recovery.

The total quantity of material processed in the old acid leach circuit during the period 1968-1979 and added to the commingled tailings amounted to approximately 92,000 tons or only about 6 percent of the total commingled pile (Pond 1).

The expansion of the mill in 1967 and the use of two circuits required the addition of several solution ponds for recycle and disposal through evaporation. It was early during the 1967-1979 period that unlined Ponds 2 through 10 were added and used for varying purposes. Pond 7, for example, stored fresh water for fire protection.

The new 1500-ton-per-day mill was constructed for a 20-year life, but it could operate for a shorter or longer period depending on ore supply and the uranium requirements of Cotter's parent. During 1981, the mill processed ore at a rate of about 800 tons per operating day.

SITE DETAIL

LOCATION

The Cotter Corporation millsite and tailings impoundments are located about 2 miles south of Canon City in Fremont County, Colorado. As shown in Figure 1, the mills and tailings impoundments occupy about 180 acres of the 640 acres (Section 16) owned by Cotter. The nine-hole Shadow Hills Golf Course is just north of the Cotter property and an idle zinc roasting plant (shut down within the last few years) is about 1 mile to the northwest.

TOPOGRAPHY

The Cotter site is located in a small subbasin of the Canon City Basin and is bounded on the south and east by a range of hills whose crest is about 300 feet above the elevation of the site. Drainage from the subbasin is into Sand Creek, an intermittent stream. The Cotter property is gently sloping to the north with an average elevation of about 5600 feet, some 200 feet higher than Canon City. The Arkansas River flows through Canon City from west to east, and is approximately 2 miles from the Cotter millsite.

CURRENT CONDITIONS OF TAILINGS

There are three tailings impoundment areas. Pond 1, about 30 acres, contains all of the commingled tailings from plant start-up (1958) to shutdown of the old mill (1979). These tailings are being moved to a segregated area within the impoundment built for the new mill. This 43.5-acre clay and membrane-lined tailings area is identified as the "secondary impoundment." The transfer should be completed, subject to weather delays, by mid-1982. Removal of the contaminated subsoil from the Pond 1 area will be undertaken after decontamination criteria are defined by the Colorado Department of Health with the advice of the NRC.

The largest tailings area is the "main impoundment," some 91.2 acres, which also is clay and membrane-lined. The secondary and main impoundments are adjacent (actually parts of a single two-cell impoundment) and were constructed over a 2-year period at a cost of $23 million. The main impoundment receives tailings from the new mill and runoff from the millsite.

There is a common dike between the main and secondary impoundments as shown in Figures 2 and 3. The current capacities, approximate installed costs, and maximum surface areas of the main and secondary impoundments are shown in Table 1.

Table 1. Cotter Corporation Tailings Impoundments

Area	Volume (yds.^{3})	Percent of Total Volume	Cost ($)	Maximum Surface Area of Storage (acres)
Main	3,682,977	68.6	15,800,000	91.2
Secondary	1,686,397	31.4	7,200,000	43.5
Totals	5,369,374	100.0	23,000,000	134.7

When the second stage of expansion is completed, the impoundment will be enlarged to have a total surface area of 175 acres and a maximum depth of 90 feet. Once the impoundment is filled with tailings, it will be drained, covered, and stabilized in accordance with regulations.

At the time of installation, the new Cotter tailings pond was the largest use of industrial-grade sheeting containing DuPont's Hypalon synthetic rubber for isolation of uranium mill tailings from the environment. The first installation step at Cotter was to cover the pond bottom with a smooth layer of compacted clay at least 18 inches thick. The membrane liner, consisting of an open weave polyester reinforcing fabric sandwiched between two sheets of Hypalon, was then installed over the clay layer. The liner was installed in panels and seamed together with a solvent-type adhesive. The job required roughly 450 panels of Hypalon weighing about 4000 pounds each, for an installed weight of 1.8 million pounds and a surface area of 6.5 million square feet. Three different thicknesses of Hypalon were used in the pond: 36 mils for the shallow area; 45 mils for mid-depths; and 60 mils for the deepest part.

The membrane was secured at the pond edge by an 18-inch-deep, 24-inch-wide anchor trench at the berm. When the dikes are raised, new lining will be attached to the old lining. The primary objective of the lining is to prevent leakage or seepage.

Twelve inches of earth was spread on top of the entire lining to protect it from possible tearing or puncture. There are subdrains beneath the clay sublining that relieve reverse hydrostatic pressure and prevent damage to the lining by uplifting. There are also overdrains for final dewatering of the tailings. The grade of the ponds ranges from a minimum slope of 20:1 to a maximum of 3:1.

At the time of the site visit, the moving of the estimated 1.5 million tons of commingled tailings from Pond 1 to the secondary impoundment was proceeding quite smoothly. Dewatering and drying of the tailings appeared to be the principal problem.

QUANTITIES

Cotter-provided data shows that 319,415 tons of ore were fed to process during the 1958-1965 period while producing U_3O_8 for sale to the AEC. From this ore, Cotter recovered 1579 tons of U_3O_8; hence 317,836 tons of tailings resulted that were attributable to Federal contracts. The finished product inventory at shutdown was 6.7 tons of U_3O_8.

Earlier generated AEC data were at variance with the above-cited Cotter data. However, the old AEC data at GJAO have been reexamined and are summarized as follows:

Ore Fed - 319,400 tons @ 0.54 percent U_3O_8.
U_3O_8 Recovered - 1,598 tons @ 93.5 percent recovery.
U_3O_8 Shipped to AEC - 1,570 tons (actual purchases: 1571.49 tons).
U_3O_8 Inventory - 28 tons.
Tailings-AEC Contracts - 313,800 tons.*

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*Assuming tons of tailings equal to tons of ore fed and adjusting for the above-finished product inventory at the end of the AEC contracts.

The above differences between Cotter and DOE figures are so small that they are inconsequential. For the purposes of this report, the figure 315,000 tons of tailings will be used. These tailings were placed in Pond 1 and, during the 1966-1979 period, were covered with tailings that resulted from uranium and byproduct production for commercial sales. A total of about 1.5 million tons of tailings was impounded in Pond 1. Hence, the portion generated under AEC contracts amounts to 21 percent of the commingled tailings currently being moved. Cotter will have a good measure of the total tailings moved from Pond 1 by use of the contractor's haulage data and by use of aerial photography to estimate volumes removed and stored in the secondary impoundment.

Cotter reports that no tailings have left the site, either accidentally or for any use.

TAILINGS MANAGEMENT HISTORY

During the early operation of the Cotter mill, all tailings were impounded in Pond 1. The alkaline-leached solids (tailings) from filtration on the drum filters were repulped and washed through two stages of thickeners prior to discharge by gravity in an open launder to the nearby tailings pond. Pond water was recycled to the mill so there was no overflow or release to the environment. The tailings resulting from production under AEC contracts are on the bottom and nearest the old mill in Pond 1. Tailings from later production (1966-1979) were impounded over the older tailings (commingled) in Pond 1 until the old mill shut down.

Cotter had planned to reprocess the commingled tailings in Pond 1 through the old mill, over a 7-year period, to recover residual uranium and molybdenum. However, with state approval, Cotter modified this plan. Cotter opted instead to move the commingled tailings as quickly as possible to the clay and membrane-lined secondary impoundment because of the drop in price for uranium, plus state concern over possible ground-water contamination. A contractor experienced in moving comparable materials, Goodfellow Bros. of Wenatchee, Washington, was brought in, and work commenced in April 1981. The contractor is required to measure all tailings moved and is paid a fixed price per cubic yard, with a contract maximum of $3.2 million. (It now appears that the original estimate of the amount of material to be moved was low, and the ultimate cost will be higher, pending contract renegotiation.) The tailings are plowed into furrows with a D-9 Caterpillar tractor to facilitate dewatering and drying. Scrapers are then used to pick up and transport the tailings to the secondary impoundment about one-quarter mile to the south. Movement of the commingled tailings is to be completed about mid-1982. Cotter plans to use the contaminated subsoil from the Pond 1 area as a capping for interim stabilization of the secondary impoundment.

Cotter has always been cognizant of possible wind transport of fine tailings and when necessary has used sprinklers on the tailings pile to minimize dusting. Chemical additives, or crusting agents, proved ineffective.

Tailings from the new mill are placed in the main impoundment where potential seepage and wind transport problems have been eliminated. The large pond keeps the tailings wet and prevents dusting.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

Canon City is the largest urban area in Fremont County, occupying approximately 2200 acres and being located about 2 miles north of the Cotter millsite. About 5 miles to the east is the town of Florence; other small communities within 5 miles of the millsite are Brookside, Coal Creek, Prospect Heights, Rockvale, and Williamsburg. In addition to these communities, many people reside outside of the incorporated areas of Canon City. In 1973, an estimated 15,976 people resided in communities located within 5 miles of the millsite. Like much of the State of Colorado, Fremont County's population has been increasing and has been projected to increase between 25 and 50 percent over the period 1975-2000. The edge of the nearest residential area is located approximately 1.5 miles northeast of the mill. The area immediately surrounding the millsite is unpopulated, and the predominant land use is livestock (cattle) grazing.

The nine-hole Shadow Hills Golf Course occupies 160 acres immediately north of the millsite. The 735-acre Royal Gorge Industrial Park, about 20 percent occupied, is about 1 mile northwest of the mill.

AIR

The climate at Canon City is semiarid and temperate with an average annual precipitation of 12 inches. Regional winds tend to be most frequently from the W-WNW-NW (47 percent) and secondarily from the E-ESE-SE (26 percent). Wind speeds are quite variable, especially in the spring, with a mean of 8 miles per hour. Thunderstorms are frequent during the summer months and may be accompanied by high winds of short duration. Tornadoes are practically unknown in the Canon City area.

Wind transport of tailings has not been a problem at Cotter since sprinklers have been used since early in the tailings removal operation whenever needed to prevent the tailings from drying. As Pond 1 was dewatered in preparation for moving the commingled tailings, dusting was a problem. The dust was mainly sodium salts brought to the surface by capillary action. These salts are so fine they are easily transported by the wind and easily seen from Canon City where complaints were voiced. Plowing the tailings into furrows brings up the moisture and prevents wind transport.

Cotter has four continuous air samplers, one at each of the quarter-section corners around the perimeter, plus one at the golf course due north of the site. Other off-site continuous air samplers include: one in the Lincoln

Park area about 3 miles to the northwest, three in the industrial area 1 mile northwest of the site, and one at a residence 5 to 6 miles to the northeast. Besides collecting particulates for analysis, each location has a TLD plus continuous radon monitor.

WATER

Alleged surface- and ground-water contamination is Cotter's biggest environmental problem. Considerable time and money have been devoted by Cotter, and to a lesser extent by others, to studying the hydrology in the vicinity of the mill, but it still is not completely understood. A comprehensive hydrologic report was prepared by Cotter early in 1981 as a condition of its mill license for presentation to the Colorado Department of Health. The report described current knowledge about the geology, surface water, aquifer characteristics, and water quality or water chemistry at, and immediately adjacent to, the Cotter millsite. One of the difficulties in trying to establish the premilling background hydrologic conditions is the presence of old, large, and geographically overlapping coal mines underlying the area.

Of concern to the state are the apparently elevated concentrations of molybdenum, selenium, and uranium in the water that is collected behind the Soil Conservation Service (SCS) dam in the Sand Creek drainage downslope from the mill, and in one well in the Lincoln Park area about 1 1/2 to 2 miles north of the mill.

The movement of fluids and chemical mass, each of which includes inputs from both natural and possible manmade sources, appears to follow a preferred path from above and through the millsite toward the SCS dam, but there is no discernible preferred path north of the SCS dam or beneath the Shadow Hills Golf Course to the north or northeast.

There are at least three separate ground-water inputs to the Lincoln Park Area: (1) Sand Creek Drainage, (2) irrigation ditches, and (3) ground-water discharge from the more permeable zones of the Vermejo Formation and Trinidad Sandstone into the alluvium underlying Lincoln Park. The relative percentages of input from each of these sources is currently undetermined. It appears that there is either a source or a sink of chemical mass in Lincoln Park because one well intercepts a source of poor quality water that other nearby wells do not intercept.

Cotter is required to pump all the water collected by the SCS dam, which includes runoff and possible seepage from the site, to its main tailings impoundment. Moving the old commingled tailings from Pond 1 will eliminate a significant potential industrial source of chemical mass and fluid input to the Sand Creek drainage.

Cotter monitors all designated surface and ground-water sites on a monthly basis. The samples are analyzed for several chemical constituents in addition to those previously mentioned. Also under way, or planned, are geophysical surveys in selected areas to better define buried channels or preferred flow paths; drilling to establish additional monitoring wells, to enhance the geophysical surveys, and to obtain water samples from underlying coal seams;

installation of continuous water level recorders in wells near a large irrigation ditch that traverses Lincoln Park; and other studies.

SURFACE CONTAMINATION

Potential surface contamination at the Cotter millsite may occur in the areas of old commingled tailings impoundment (Pond 1), solution storage ponds, ore storage, old millsite, and possibly in the drainage of Sand Creek from the Cotter property to the SCS dam.

Movement of commingled tailings from the 30-acre Pond 1 area will enable Cotter to determine the amount of subsoil and sandstone that will require excavation. A subsoil sampling plan proposed by Cotter was approved by the state (CDH), and was commenced by Cotter on February 1, 1982. Cotter tentatively plans to use the contaminated subsoil to cover the commingled tailings moved to the secondary impoundment and thereby provide interim stabilization until the tailings are covered with commercial tailings or until final reclamation.

The old unlined solution storage ponds, totaling about 10 acres, will be cleaned as part of the tailings moving project. This cleanup, or decontamination, could add an estimated 0.5 million tons of dirt to the 1.5 million tons of tailings already being moved.

The extent of surface contamination in the drainage of Sand Creek currently is unknown but may be related to the several natural springs upgradient of the SCS dam and the possible seepage from old tailings and solution ponds. Continuing studies of the hydrology, and sampling of soils and subsoils plus water and sediment in the dam, will enable Cotter to more accurately define the magnitude of this problem.

Surface contamination in the old mill and ore storage areas will be cleaned up as part of the decommissioning.

In view of the results of repeated analysis of air, soil, and plant life samples, Cotter does not believe there is a significant surface contamination resulting from radioactive particulate emissions from the mill and windblown tailings. This also will require evaluation as part of decommissioning and reclamation at shutdown.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

The only option currently considered by Cotter is the on-site stabilization of all tailings, and other radioactive materials from decommissioning, in the clay and membrane-lined impoundments previously described. Final stabilization and reclamation may not be accomplished for 20 or more years in the future. Cotter has deposited with the State of Colorado $210,000; the principal and interest earned thereupon is to be used to fund long-term maintenance of the tailings impoundment after stabilization. Cotter has also provided the state with a bond to assure proper decommissioning, decontamination, and reclamation.

Interim stabilization of the commingled tailings, currently being moved to the secondary impoundment, will be accomplished late this year or in 1983, by placement of the Pond 1 subsoil over the tailings.

Moving the commingled tailings from the Pond 1 area is estimated to cost about $3.2 million (the contract maximum). Tailings resulting from AEC contracts constitute about 21 percent of the commingled tailings.

DISCUSSION OF FEASIBLE COST-SHARING PLANS

Cotter officials have given considerable thought to this matter as indicated by the attached draft, "Preliminary Evaluation," dated December 8, 1981. The concept advanced by Cotter is that the Federal Government should share in specific items of cost with the Government portion being determined by a formula for each item. The concept is site- and method-specific. A preliminary cost estimate by Cotter indicates the total costs to be shared, as described in the attachment, would be in the range of $10 to $20 million.

Cotter also believes the DOE should share in the cost of disposal and stabilization of tailings resulting from Cotter's processing of ore from DOE mining leases. Additionally, Cotter officials feel special recognition of some sort should be accorded Cotter for assistance to the AEC by removing the radioactive residues from the St. Louis area. Finally, Cotter calls attention to the need to give some recognition to the time value of money in any provision for cost-sharing.

ATTACHMENT

AMC/DOE Commingled Tailings Effort, Cotter Corporation Preliminary Evaluation, Draft, December 8, 1981

FIGURES

Figure 1. Location Map

Figure 2. Plan Map

Figure 3. Aerial Photograph (on file at Grand Junction Area Office)

ATTACHMENT 1
COTTER CORPORATION PRELIMINARY EVALUATION

ITEMS OF COST

A. Isolation facility (secondary impoundment). Design, engineering, site preparation, and construction. Includes cost of reclamation bond and maintenance fund.

B. Transfer of tailings to isolation facility.

C. Transfer of tailings-contaminated soil to isolation facility. Includes off-site contamination due to runoff (SCS Res.).

D. Reclamation of old tailings storage area.

E. Interim cover of old tailings in isolation facility.

F. Final reclamation of isolation facility.

G. Hydrologic and ground-water studies. Includes installation of wells, sampling and analytical work, hydrogeologic work, etc.

H. Installation, maintenance, and operation of monitoring systems and interception trenches for isolation facility. Includes well monitoring required by license.

I. Decontamination and disposal of old mill. Includes reclamation of site and disposal of contaminated soil in isolation facility.

J. Ground-water and surface-water pumpback and storage.

K. Other future liabilities.

L. Dust control on old pond and buttress on old dike.

COST-SHARING FORMULAE

Basic Ratio (B. R.) = AEC Tons over Total Tons

A. DOE cost = total cost x B.R. x tailings volume over total volume capacity of the isolation facility.

B. DOE cost = total cost x B.R.

C. Transfer: DOE cost = total cost x B.R.
Storage: DOE cost = total cost of A x B.R. x soil volume over total volume capacity.

D. DOE cost = total cost x B.R.

E. DOE cost = total cost x B.R.

F. DOE cost = total cost x B.R. x tailings volume over total volume in place.

G. Past work: DOE cost = total cost x B.R.
Future work: DOE cost = total cost as incurred x B.R.

H. Same as G except x tailings volume over total volume capacity.

I. Decontamination: DOE cost = total cost less salvage x B.R.
Transfer to isolation of mill and soils: DOE cost = total cost x B.R.
Storage: DOE cost = total cost of A x B.R. x volume transferred over total volume capacity.
Reclamation: DOE cost = total cost x B.R.

J. Construction, operation, and maintenance of pumpback system.
Past work: DOE cost = total cost x B.R.
Future work: DOE cost = total cost as incurred x B.R.
Storage:
Past: DOE cost = total cost of A x B.R. x pumpback volume less evaporation over total volume capacity.
Future: Same as past, but paid annually, as incurred. If pumpback volume significantly accelerates enlargement of the impoundment (main), DOE should pay a proportionate share of the cost.

K. DOE cost = total cost x B.R.

Note: All of the above costs already incurred by the mill operator should be adjusted to reflect the time value of money.

All of the above is a preliminary evaluation, is site- and method-specific, and may not consider all reasonable costs. For example, a case could be made that the Government should bear the total of all costs of such tailings isolation, stabilization, monitoring, and other corrective actions. The rationale is that development of the industry was stimulated and nurtured by the Government under then-existing law, regulatory structure and guidance, with then state-of-the-art technology and methodology.

Corrective actions required now, and in the future, because of lawful changes in the Government's position should be paid for by the Government.

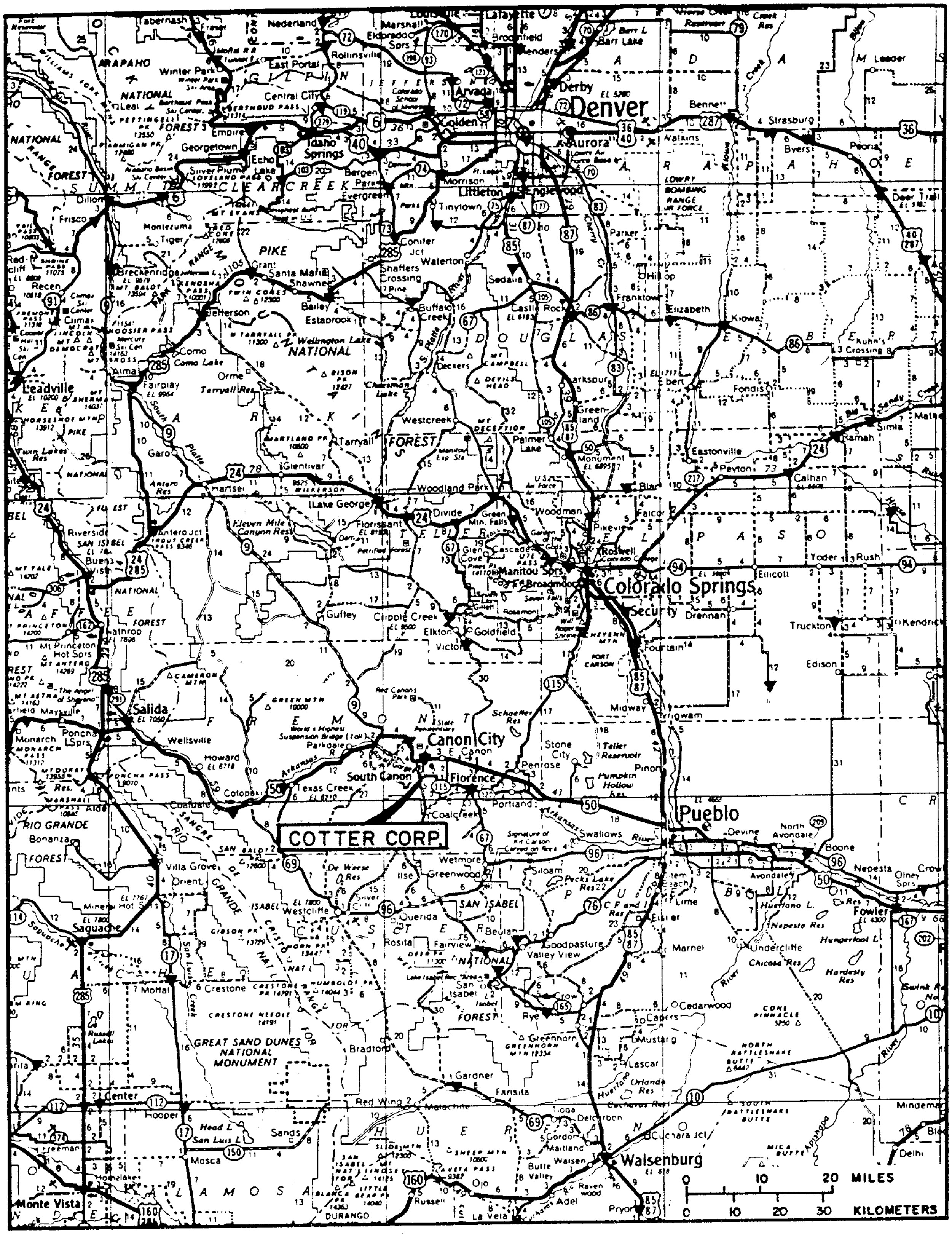

Figure 1. Location Map: Cotter Corporation, Canon City, Colorado

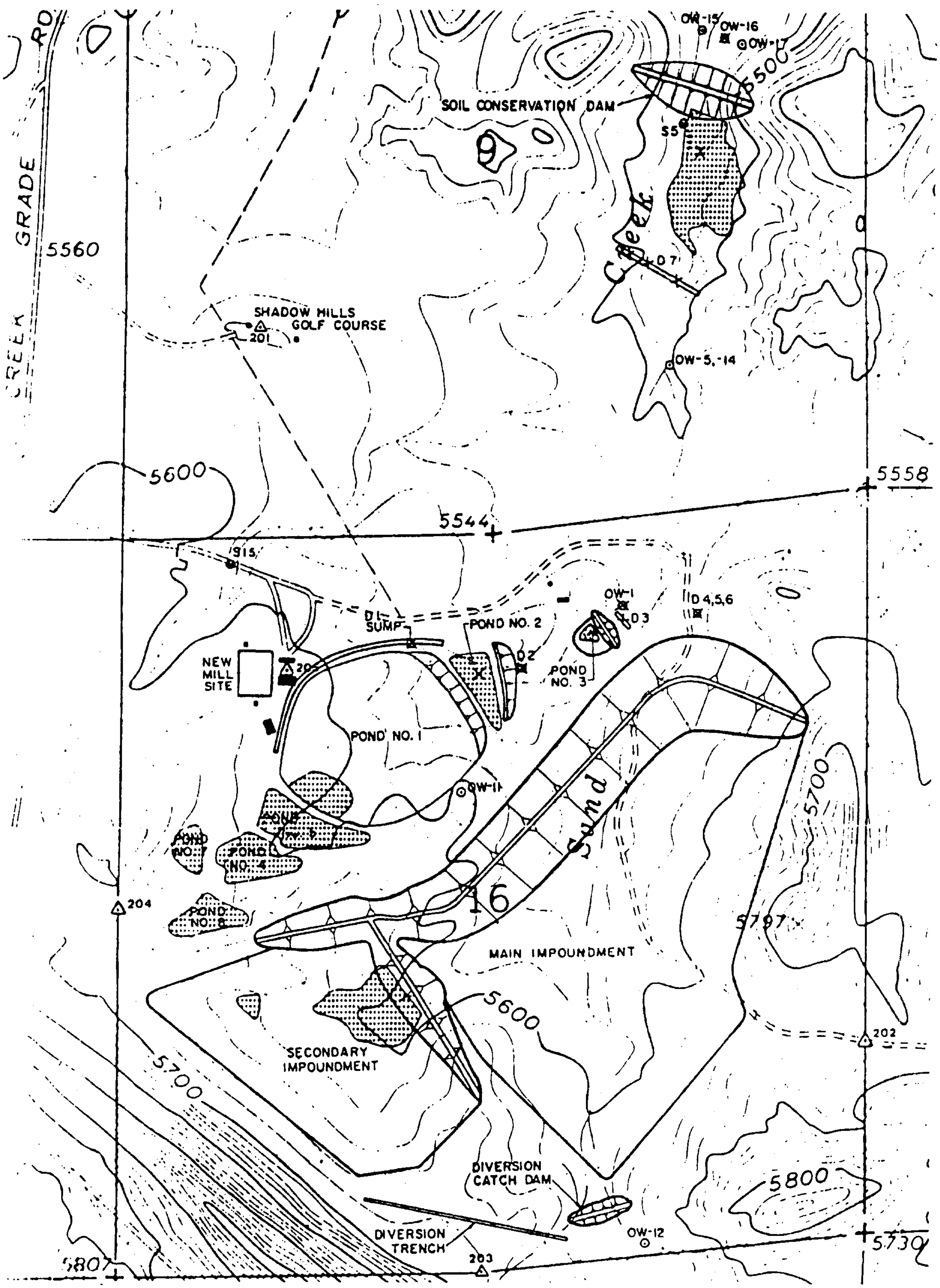

Figure 2. Plan Map: Cotter Corporation, Canon City, Colorado

SITE REPORT: UNION CARBIDE CORPORATION
Uravan, Colorado

INTRODUCTION

The Union Carbide Corporation (Carbide) operated a uranium-vanadium ore processing plant, or mill, at Uravan, Colorado, during the period 1949-1970 to produce uranium for sale to the Federal Government for its defense programs. About 1968 Carbide began producing some uranium for sale in the commercial market, and since 1970 all sales have been commercial. Thus, tailings from the earlier operation under Government contracts were covered by or commingled with tailings from later operations.

Union Carbide officials provided most of the references cited at the end of this report.

BACKGROUND AND HISTORY

OWNERSHIP

The mill plus related facilities, the tailings impoundments, and the solution ponds are located on land owned by Union Carbide Corporation and on patented and unpatented mining, placer, and millsite claims located on public lands. The original milling facility and the townsite were acquired by the United States Vanadium Company, a subsidiary of Carbide, in 1928 from Standard Chemical Company.

The earliest source materials license for processing uranium ore at the Uravan mill was issued by the AEC. In 1968, Colorado became the 18th Agreement State and assumed regulatory and licensing authority over the uranium mills in the state. The Uravan license was to have expired in 1975. Prior to that date, a renewal application was made by Carbide and for the past 6-1/2 years some 35 agency groups have been participating in the evaluation of the facility. License renewal is still pending.

PRODUCTION HISTORY

The mining and milling of the carnotite-type ores of the Uravan Mineral Belt have been passed through a number of phases in which the relative importance of vanadium, uranium, and radium products varied. In the early 1900s, some high-grade ore was shipped to France for radium recovery by the Curies. However, most of the ore mined until about 1910 was processed for its vanadium and uranium content, the uranium being used as a coloring agent in ceramics and glass. During the period 1911-1923, radium production was paramount.

The earliest recorded production at Uravan was primarily for radium. From 1915 to 1923, the Standard Chemical Company operated a 50-ton-per-day ore concentrator at the site of the present Uravan plant. This operation, known as the Joe Junior Mill, produced significant quantities of concentrate containing about 4 percent U_3O_8 and 12 percent V_2O_5. The concentrate was shipped to Standard's plant in Pennsylvania where the uranium, radium, and vanadium were separated. The Uravan plant shut down after discovery of the high-grade pitchblende deposit in the Belgian Congo and the drop in the world price of radium. There is no record of tailings disposal practices of the Standard concentrator, but an estimated 100,000 tons of sands could have resulted from this earliest operation.

The U.S. Vanadium Company, a Union Carbide Corporation subsidiary, purchased Standard's holding in 1928, and in 1935 constructed a mill to recover vanadium. Operation commenced in 1936 with the uranium and radium being discarded in the tailings. Mill capacity is thought to have been in the range 100-200 tons of ore per day. Vanadium production continued until the events of World War II diverted Carbide's efforts.

Early in 1942, after urgent contacts by the Army's Manhattan Engineer District (MED), Carbide built a small pilot plant to develop process technology for recovering the uranium from the vanadium mill tailings. In December 1942, the MED entered into a contract with Carbide for "green-sludge" production at Uravan. Additionally, the MED constructed a Government-owned plant at the Uravan site to process vanadium mill tailings provided both by Carbide at Uravan and by the Vanadium Corporation of America (VCA) at Naturita. The vanadium and uranium recovery plants operated until 1945 when the demand for both metals dropped and all facilities were shut down.

No records are available on the actual quantities of tailings processed, but AEC records show that by the end of 1944 Carbide had produced 150 tons U_3O_8 in green sludge (20 percent U_3O_8) and, along with VCA, had provided vanadium tailings for almost 400 tons U_3O_8 produced in the Government-owned plant at Uravan. Carbide's wartime efforts also included the operation of a Government-owned plant at Durango, Colorado, where about 80 tons U_3O_8 in sludge were produced, and operation of a refinery at Grand Junction from 1943 to 1946 where all the green sludge was processed to further concentrate the uranium.

The Uravan mill was reactivated by Carbide in 1948 in response to the AEC's efforts to stimulate domestic uranium production. At that time, the uranium-vanadium ores of the Uravan Mineral Belt (UMB) constituted the only known significant reserves in this country. However, any increase in uranium production from the carnotite ores would be accompanied by an increase in vanadium production. For the AEC to assure an adequate supply of uranium, it was necessary to provide insurance that this supply would not fall off at times when the commercial demand for vanadium was low. Therefore, the uranium contracts with vanadium producers such as Carbide included guarantees to purchase vanadium, within limits and at a fixed price, whenever the commercial market was inadequate to absorb the vanadium production. This permitted these mills to operate at full capacity for uranium output. Consequently, the AEC purchased vanadium in the form of fused vanadium oxide during the period 1949 until June 30, 1959. A total of 28,602,064 pounds V_2O_5 was bought, at a cost of about $1 per pound, from six mills treating UMB ores.

By 1950, the Uravan mill had a capacity of about 500 tons per day. In 1955, with the construction of a new mill utilizing improved uranium process technology, the capacity was expanded to 1000 tons per day. By 1976, the Uravan mill was capable of treating 1300 tons per day.

During the Federal contracts period since World War II, 1949 through 1970, Carbide processed at Uravan 5,729,000 tons of ore averaging 0.24 percent U_3O_8 and 1.20 percent V_2O_5. A total of 12,294 tons of U_3O_8 was recovered, or 91.2 percent of the U_3O_8 present in the ore. About 3 percent of this total U_3O_8 production (364 tons) was sold commercially, during the period 1968-1970. All the rest of the uranium production, specifically 23,857,710 pounds U_3O_8, was purchased by the AEC at an average price of $9.34 per pound.

During the period of AEC contracts, when excess vanadium production could be sold to the AEC, 1949 through March 31, 1961, Carbide produced at Uravan a total of about 34,000,000 pounds V_2O_5. Of this, 9,738,791 pounds V_2O_5, or 29 percent of production, was purchased by the AEC.

Table 1 summarizes the U_3O_8 and V_2O_5 purchases by the AEC from the Uravan mill.

Table 1. AEC Purchases of U_3O_8 and V_2O_5, UCC-Uravan

Contract No.	Period (CY)	U_3O_8 Pounds	U_3O_8 Price ($/lb.)	V_2O_5 Pounds	V_2O_5 Price ($/lb.)
AT(05-1)-036	1949-1961	10,719,208	11.18	9,738,791[a]	0.98
AT(05-1)-795	1961-1970	13,138,502	7.84	None	
Totals	1949-1970	23,857,710	9.34	9,739,791	0.98

[a]Total AEC obligation under this contract could have been 28,350,000 pounds V_2O_5 (fused oxide).

Since termination of the last AEC contract (December 31, 1970), Carbide has continued to produce uranium and vanadium for sale in the commercial market. However, production has not been continuous as the Uravan mill was shut down for about 6 months in 1981 due to poor market conditions.

PROCESS DESCRIPTIONS AND MAJOR CHANGES

The first mill at Uravan (Standard Chemical Company) was actually an upgrader. After crushing and grinding, a wet sand-slime separation was used to produce a slime concentrate that was dried and shipped to Pennsylvania for chemical processing.

Carbide's earliest vanadium mill used the classical salt-roast process. The dry ground ore was roasted with salt (sodium chloride) in a multiple hearth roaster. The hot calcines were quenched into water and leached in percolation tanks where the vanadium was selectively dissolved. The vanadium was precipitated, washed, and dried or fused before shipment. In 1939 Carbide added an acid-leach step to extract additional vanadium.

The plants that operated during World War II for recovery of uranium consisted of leaching the salt-roast vanadium tailings with sulfuric acid and filtrating to separate a clear leach liquor or solution. After heating the solution and adding metallic iron to reduce the vanadium, caustic soda was added to precipitate the "green sludge," a uranium-vanadium product that was further refined at Grand Junction.

In 1955 when Carbide constructed a new mill, referred to as the "B" plant, the salt-roast process was abandoned in favor of "hot-acid leaching." Both uranium and vanadium are taken into solution during the highly oxidizing two-stage acid leaching. The solids (tailings) are washed in an eight-stage countercurrent decantation (CCD) circuit. The uranium-vanadium solution is clarified and then passed through ion-exchange columns where the uranium is removed and then precipitated with ammonia to produce concentrate. The vanadium solution has been treated either to make fused vanadium oxide, ferric vanadate, or higher vanadium grade liquors for shipment elsewhere for vanadium recovery. Fused vanadium oxide production at Uravan terminated in February 1962.

The Uravan mill at various times has processed ore from more than 200 mines. Some of the ore came from AEC mining leases on lands withdrawn from entry by the Government. During the AEC contracts period, about 75 percent of the ore came from Carbide's mines, the remainder was purchased from independent mine operators.

SITE DETAIL

LOCATION

The total facility, which consists of the mill, mine/mill offices, warehouses, townsite, and solid and liquid waste storage areas, is situated adjacent to the San Miguel River and occupies portions of Sections 27, 28, 29, 33, and 34, T. 48 N., R. 17 W., 6th P.M. in Montrose County, Colorado. It is 50 airline and 90 road miles south-southwest of Grand Junction, Colorado. Solid wastes or tailings are mostly in Section 33, liquid wastes in Section 28. The site location with respect to population centers and mining areas is shown in Figure 1. Figure 2 shows the layout of the entire complex.

TOPOGRAPHY

The topography of the general area (within 25 miles of Uravan) is characterized by steep narrow canyons cutting through high mesas. Canyon walls consist of cliffs and rims as a reflection of the sedimentary nature of the geology. Elevations range from around 5000 feet above sea level in canyon floors to around 6500 feet on tops of mesas. The plant site itself displays such topography, i.e., some of the facilities are along the San Miguel River at an elevation of 5000 feet while other portions (including the tailings) are on Club Mesa at an elevation of 5500 feet. Vegetation, briefly described, consists of pinon-juniper conifers on the mesas and canyon slopes grading into desert shrub on canyon bottoms accompanied by grasses which associate with each type of vegetation.

The mill is divided, by topography, into two areas. The "B" plant, consisting of ore receiving, crushing, grinding, leaching and solids washing by CCD, is situated on the canyon rim south of and several hundred feet above the river. The older "A" plant, located on the canyon floor adjacent to the river, separates the uranium and vanadium. Horizontally, the two plants are about 1500 feet apart, as shown in Figure 2.

CURRENT CONDITIONS OF TAILINGS

Tailings created since 1949 are stored in three piles, namely "the Sludge Pond Pile," Tailings Piles Nos. 1 and 2 (combined), and Tailings Pile No. 3. Precise location of much of the pre-1949 tailings is not known.

There are six large evaporation ponds along the river downstream from the plant on what was previously known as the Club Ranch. Effluent is also delivered to the top of Club Mesa where it is emitted from sprays and evaporated. In addition, there is a small pond for gathering liquid mill waste located near the "A" plant by the river. A "boneyard" has been established along the slope of Club Mesa for storing radioactive used equipment and other junk.

The "Sludge Pond Pile," about 4.5 acres in size and 20 feet in height, is located directly across the San Miguel River from the mill. In Figure 2, this pile is labeled "Emergency Ponds." Tailings were deposited in this pile from January 1950 through August 1956 from production for AEC contracts. The pile has been shaped for depositing and settling sludge, which is removed from time to time and transported to the top of Club Mesa, ultimately to be placed in a tailings pile.

Tailings Piles Nos. 1 and 2, located on the same bench on Club Mesa as the "B" plant, physically constitute one pile, having a combined size of about 58 acres. As of May 1981, it had reached a height of around 155 feet (elevation 5496). At reclamation, it will have attained a height of 170 feet (elevation 5510).

During the period September 1960 through July 1962, tailings were placed in Tailings Pile No. 1 (the north end of the combined pile). Introduction of tailings into Pile No. 2 commenced in July 1962. (Between August 1956 and September 1960, tailings were deposited in two separate piles, sand and slime, and later reprocessed for vanadium.) As Pile No. 2 has built up, it has, to a large extent, encompassed Pile No. 1. It is still in use alternatively with Pile No. 3.

Tailings Pile No. 3, 22 acres in size and also located on a bench below the top of Club Mesa, began receiving tailings in 1968 in an alternating system with Pile No. 2. As of May 1981, tailings had reached a depth of about 110 feet. At final impoundment, tailings in this pile will be around 125 feet deep.

Retention of tailings in Piles No. 1, 2, and 3 is accomplished by dikes on the outward face of the pile and by the side of Club Mesa on the inward face.

The six Club Ranch Evaporation Ponds receive vanadium circuit raffinate via a 6-inch acid-proof pipeline from the mill. The ponds have a combined evaporative surface of 36 acres. The annual evaporation is about 40 inches. Spray evaporation at a site near the top of Club Mesa and within the Club Ranch Pond system increases the evaporation rate. Deposits of salts tend to accumulate in the ponds and periodically are cleaned out.

QUANTITIES

Assuming that 1 ton of ore fed to process results in 1 ton of solid dry tailings, the data shown in Table 2 indicate that the total tailings attributable to production of U_3O_8 for sale to the AEC through 1970 was 5,551,000 tons, or about 56 percent of the total tailings impounded through 1981.

Tailings generated prior to 1949, for U_3O_8 sales to the Army, are not included in the above figure. Based on the total uranium produced by the Uravan plants (550 tons U_3O_8 for both the Carbide and the Government-owned plants), one could assume that another 150,000 tons or so of tailings could be attributable to the wartime effort. However, adding that quantity to the totals through 1981 would increase the portion attributable to Federal contracts by only 1 percent. Also, there is no record of the disposition of pre-1949 tailings at Uravan.

The 5,551,000-ton figure for total tailings attributable to AEC contracts is somewhat greater than the 5,318,000-ton figure previously estimated by Carbide in 1978. The difference appears to be due to Carbide's applying a weight reduction factor for dissolution, e.g., 4 percent for ore fed to the old salt-roast process and 6 percent for ore fed to the hot acid leach. Without use of those factors, there is good agreement on tonnages of tailings.

Table 2. Uravan Production Data

	Production Period		
	1949–1970	1971–1981	1949–1981
Ore Fed (tons)			
AEC Contracts	5,551,186	None	5,551,186
Commercial Sales	177,592	4,148,000	4,325,592
Totals	5,728,778	4,148,000	9,876,778
U_3O_8 Produced (lbs.)			
Sold to AEC	23,857,710	None	23,857,710
Sold to Others	762,266	N.A.	N.A.
Totals	24,619,976	N.A.	N.A.
	Production Period		
	1949–1961[a]	1961–1970	1949–1981
V_2O_5 Produced (lbs.)			
Sold to AEC	9,738,791	None	9,738,791
Sold to Others	24,286,973	N.A.	N.A.
Totals	34,025,764	N.A.	N.A.

[a]AEC was obligated to purchase fused V_2O_5 until April 1, 1961, up to a maximum of 28,350,000 pounds.

It has been suggested that it would be appropriate to consider adjustments to the tonnage of tailings attributable to Federal contracts for coproducts or byproducts sold during the terms of such contracts. For Uravan production, several alternatives to the base case formula (1) might be considered.

Base Case Formula (1): $\frac{A}{B} \times C = D$, where

A = Total U_3O_8 purchased by AEC (pounds) = 23,857,710.
B = Total U_3O_8 produced during AEC contracts (pounds) = 24,619,976.
C = Total ore fed to process (tons) = 5,728,778.
D = Total tailings attributable to AEC contracts (tons) = 5,551,186.

One adjustment could be made on the basis of V_2O_5 sold to the AEC and total V_2O_5 that could have been produced. In this case, 11.4 pounds of V_2O_5 are considered the equivalent of 1 pound of U_3O_8 based on comparable values, i.e., U_3O_8 at \$11.18 per pound and V_2O_5 at \$0.98 per pound. Then, using the following formula (2), the adjustment might be:

Formula (2): $\frac{A + E \div 11.4}{B + F \div 11.4} \times C = G$, where

E = Total V_2O_5 sold to AEC (pounds) = 9,738,791.
F = Total V_2O_5 that could have been produced through 1970 based on 1.2% V_2O_5 in ore fed and 70% recovery (pounds) = 96,243,470.
G = Total tailings attributable to AEC contracts adjusted for total V_2O_5 production (tons) = 4,281,890.

Another alternative is to adjust for V_2O_5 produced and sold to the AEC, but only to the extent of the maximum obligation of the AEC to purchase V_2O_5 from Uravan. In this instance, the formula would be:

Formula (3): $\frac{A + E \div 11.4}{B + H \div 11.4} \times C = I$, where

H = Total V_2O_5 that the AEC was obligated to buy, 11-1/4 years at 2,520,000 lbs./yr (pounds) = 28,350,000.
I = Total tailings attributable to AEC contracts, adjusted for AEC obligation to buy V_2O_5 (tons) = 5,222,653.

Various other approaches could be considered to adjust for vanadium production, but all are complicated by the fact that good records do not exist. Because the commercial market for V_2O_5 was erratic and unpredictable, Uravan vanadium production fluctuated accordingly. Fused V_2O_5 production at Uravan ceased in 1962, but even prior to that, beginning in November 1956, vanadium production was cut back and tailings were impounded for possible future treatment to recover residual vanadium. Tailings reprocessing started late in 1963 on slimes and early in 1966 on the sands, and was finally completed in 1971. Transfers of vanadium-bearing products, such as ferric vanadate, slimes, solutions, etc., from Uravan to Rifle make it difficult, if not impossible, to now trace the details of vanadium production at Uravan.

Another approach that has been suggested is that tailings reprocessed for commercial purposes to recover uranium or byproducts should no longer be included in the quantities attributable to Federal contracts. At Uravan, tailings were treated for several years to recover vanadium but no accurate records are available. If one assumes all tailings impounded between August 1956 and September 1960 were fed back to process, the total tonnage to be deducted would be about (4 yrs. x 350 days/yr. x 1000 tpd) 1,400,000 tons, leaving 4,151,000 tons of tailings attributable to AEC contracts.

Table 3 summarizes the possible adjustments of tailings at Uravan that were considered above.

Table 3. Possible Adjustment to Tailings Attributable to AEC Contracts at Uravan

Alternative	AEC Contracts Tailings (tons)	AEC Percent of Total at 1/1/82[a]
Base Case Formula (1)	5,551,000	56
Formula (2) V_2O_5 Adjusted	4,282,000	43
Formula (3) V_2O_5 Adjusted	5,223,000	53
For Tailings Reprocessing	4,151,000	42

[a]Total tailings as of 1/1/82 was 9,876,778 tons.

Union Carbide does not support the concept of allocating Government responsibility for commingled tailings management based on either byproduct or coproduct concepts. Carbide contends the tailings at Uravan are present as a result of the Government's call for uranium production and are not present in any greater or smaller quantity because of the vanadium recovered or not recovered. Finally, Carbide states that much of the vanadium in the Uravan ore had to be recovered to make the uranium concentrate suitable for further processing and to meet contract specifications.

Carbide also believes that the tailings resulting from production of uranium for the Army during the 1942-1945 period should be included. In this case, the total tailings attributable to all Government uranium procurement contracts and the total tailings at Uravan as of January 1, 1982, would be as shown in Table 4.

Table 4. Uravan Tailings Attributable to AEC and Army Contracts, 1942-1981

Government Agency	Government Contracts: Tailings (tons)	Total Tailings at 1/1/82 (tons)	Government Percent of Total
AEC	5,551,000	9,877,000	56
Army	150,000	150,000	100
	5,701,000	10,027,000	57

The addition of the estimated pre-1949 tailings does not increase significantly the proportion of the Uravan tailings attributable to Government contracts.

With respect to future production, Carbide has delivery commitments which would require operation through 1985, although another Carbide uranium operation could contribute. Given favorable market and price conditions, resources are adequate for 15 years continued production at Uravan. Present remaining tailings storage capacity is about 1-1/4 million tons, or less than 3 years operation at full-rated capacity.

TAILINGS MANAGEMENT HISTORY

Currently, the tailings ponds receive the waste slurry from the last thickener in the CCD circuit of the "B" plant at a rate of about 220 gpm. After settling, a portion of the liquid is decanted and returned to the mill as a wash solution for CCD. Seepage collected from the toe of the dam is recycled to the mill. The raffinate from the vanadium solvent extraction circuit is pumped to the six Club Ranch evaporation ponds across the river.

The Uravan mill is the only uranium mill in the United States directly discharging liquid effluent. A composite waste stream consisting of tailings pond seepage, concentrate thickener overflow, cooling water, and occasionally the neutral solution from lime treatment of vanadium solvent extraction raffinate is released to the San Miguel River. These effluents first are treated with barium chloride, settled in a series of ponds, monitored, and discharged under a National Pollutant Discharge Elimination System (NPDES) permit.

Tailings generated during earlier operation when the salt-roast process was used were more granular than current tailings.

Although no figures are available, it is thought that a portion of the tailings from the pre-AEC era found its way into the river and was transported downstream.

Between August 1956 and September 1960, Carbide impounded the tailings sands and slimes separately. Late in 1963, Carbide began treating the slimes, and in 1966 the sands, for vanadium recovery. The retreated sands and slimes were combined with the tailings from current production. Tracing the exact history of tailings management at Uravan is difficult because of the site's long life, personnel changes, and lack of records.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The town of Uravan encompasses 184 acres and is spread out along the canyon floor on a southeast-to-northwest axis that roughly parallels the San Miguel River. It includes housing for mining and milling employees plus other basic structures, such as a post office, general store, elementary school, recreation hall, and a dining hall. Population centers near the Uravan mill and the estimated 1980 populations are:

Town	Distance from Uravan (miles)	Direction from Uravan	Est. 1980 Population
Uravan	0	-	510
Nucla	15	SE	1026
Naturita	17	SSE	810

The general area is sparsely populated, about 3 people per square mile within a 25-mile radius.

AIR

The major sources of radon at the millsite are the ore pad, ore stockpile area, and the tailings areas. Rather high concentrations of radon are found directly over ore and tailings piles, but they decrease significantly with increasing distance from the mill.

Because the climate at Uravan is semiarid, with only about 10 inches of precipitation a year, the tailings must be kept moist to prevent blowing of dusts.

To monitor the windborne and gamma radiation aspects, Carbide presently operates eight continuous ambient air particulate collection stations, including a background site, and monitors for particulates, U-Nat, ^{230}Th ^{226}Ra, ^{210}Pb, and vanadium. Sites extend from directly downwind of disposal sites, 200 yards to 4 miles, upwind and downwind. In addition, a network of 23 sites exist where continuous radon gas monitoring is ongoing. These sites are also utilized quarterly for monitoring radon flux emanation rates and radionuclide composition of the first 5 centimeters of topsoil. The soil and radon flux measurements began in 1982. External ambient air monitoring gamma measurements are integrated monthly at the eight ambient air monitoring sites. Two meteorological stations are operated, one near the tailings, one in the valley, giving data on wind speed and direction along with temperature, total wind run, and humidity.

WATER

The Uravan mill is located on the San Miguel River which joins the Dolores River a few miles downstream. The Dolores flows into the Colorado River in Utah above Moab. Various creeks flow into the San Miguel, but only during runoff periods following occasional storms.

A water table, or saturated zone, exists at about the same elevation as the San Miguel River. Other ground water is present above that moving along bedding planes, percolating downward along fractures, or in smaller perched saturated zones. The geohydrology is complex and not known in detail.

Because of the elevation differential and the geohydrology which accompanies sedimentary geology, there does not appear to be a significant amount of leaching from the present tailings into the water table. Some 15-20 gallons per minute migrates from the evaporation ponds into the San Miguel River.

Carbide not only routinely samples the river water both above and below the site, but it also monitors the water in several wells on- and off-site.

SURFACE CONTAMINATION

The extent of on-site surface contamination, except under the tailings pile, will be assessed by Carbide at the time of decommissioning. The extent of off-site contamination, especially that due to windblown tailings, is not presently known. However, based on gamma radiation surveys, soil sampling, and radon flux measurements it is not considered to be a significant potential health hazard to residents of the Uravan area. The natural radioactivity in the Uravan area tends to mask any surface contamination resulting from milling operations.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

This topic will be dealt with in three parts, namely, (1) interim stabilization of existing commingled sites, (2) final stabilization and reclamation of commingled sites, and (3) future tailings sites (not commingled).

INTERIM STABILIZATION (COMMINGLED PILES)

Stability studies in 1978 and 1979 identified the need to stabilize the embankments on Tailings Piles Nos. 2 and 3. Hence, a two-phase program costing $11,600,000 was carried out in 1980 to remedy seepage along the toe (Phase I) and prepare a foundation of gravel and sandstone rock at a flatter slope along the lower 60 feet of the embankments (Phase II). In addition, a seepage collection system was installed along the berm. The foregoing measures were designed to meet the requirements of the Colorado Department of Health and NRC.

FINAL STABILIZATION (COMMINGLED PILES)

Two alternative plans for final reclamation of commingled tailings have been developed: Scheme A which Carbide has adopted, and a second plan (submitted to the Colorado Department of Health, May 30, 1980) upon which to base financial surety estimates. These plans have been estimated to cost $10,135,000 and $13,640,000, respectively. Neither estimate includes costs for cleaning up, decommissioning, and reclaiming the millsite upon decommissioning nor do they include the long-term maintenance fund required by NRC and the State of Colorado. All aspects of the surety plan are estimated to cost $23,692,000.

Scheme A would entail the following:

(1) Place sludge pond tailings and other contaminated materials on top of existing tailings piles, cover areas from whence they came with 1 foot of random fill, and revegetate.
(2) Reclaim Tailings Piles Nos. 1, 2, and 3 with in-place side slopes of 3h:1v (the existing slope) and 3 percent slope on top.
(3) Cover the side slopes with 1 meter of compacted clay, 0.7 meter of random fill, and 1.3 meters of rock borrow.
(4) Cover the top with 1 meter compacted clay, 1.4 meters of random fill, and 0.6 meter of rock borrow.

The so-called financial surety plan would cut the slopes back to 5h:1v beginning at the toe with a 3 percent slope on top. Cover throughout would consist of 1 meter compacted clay, 1.3 meters random fill, and 0.7 meter rock cover. The process would generate excess tailings and remove some of the rock associated with interim stabilization. The rock would be saved as cover material; the excess tailings, along with the sludge pond tailings and other contaminated material, would be placed in a newly constructed clay-lined area. The plan also calls for measures to divert surface-water flow away from the tailings area.

FUTURE TAILINGS SITES

Existing tailings piles have room for less than 3 years operation at sustained operating rates. Hence, Carbide is investigating sites for future use, primarily on Spring Creek Mesa, north of the San Miguel River.

DISCUSSION OF FEASIBLE COST-SHARING PLANS

The cost-sharing plans or approaches discussed with Carbide officials included the following:

1. <u>Proportionality of AEC-Related Tailings to Total at Decommissioning</u>
   This approach would be based on the following formula:

   Share of U.S. Government Cost (%) = $\frac{A \times 100}{B + C}$, where

   A = Tons of tailings resulting from sales to AEC.
   B = Total tailings as of 12/31/81.
   C = Tailings generated 1/1/82 to decommissioning of the mill.

2. <u>Proportionality of AEC-Related Tailings to Total at January 1, 1982</u>
   This plan would compute the percentage using only A and B in the formula and confine sharing to stabilization and reclamation of Sludge Pond Pile and Tailings Piles Nos. 1, 2, and 3.

3. <u>Based on Acreage</u>
   As of January 1, 1982, AEC-related tailings were located in about 85 acres and composed 56 percent of the total tonnage. Hence, the U.S. Government could be said to be responsible for reclamation of 48 acres, which could be reclaimed whenever the operator chose.

4. Adjustment for Vanadium
The percentage derived in options (1) and (2), and used in option (3), could be adjusted downward to take into account the fact that ore fed to process for sale of U_3O_8 to AEC also contained V_2O_5, most of which was sold to commercial users. Two possible adjustments for V_2O_5 production are set forth in Table 3 which is followed by Carbide's comments on this concept.

5. Adjustment for Reprocessing Tailings
This approach was not formally discussed with Carbide officials but the possible adjustment also is shown in Table 3.

Carbide's position is that costs borne by the Government should be related to the configuration of the Tailings Piles Nos. 1, 2, and 3 and the Sludge Pond Pile as of January 1, 1971. Figure 3 is an aerial view of the 1970 situation. The total acreage was not markedly different than now; however, the height was not as great and the embankment slopes were 2h:1v, rather than 3h:1v as later shaped. Carbide has estimated the cost of imposing the Scheme A plan on the January 1, 1971, configuration to be $10,475,000 in 1980 dollars.

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FIGURES

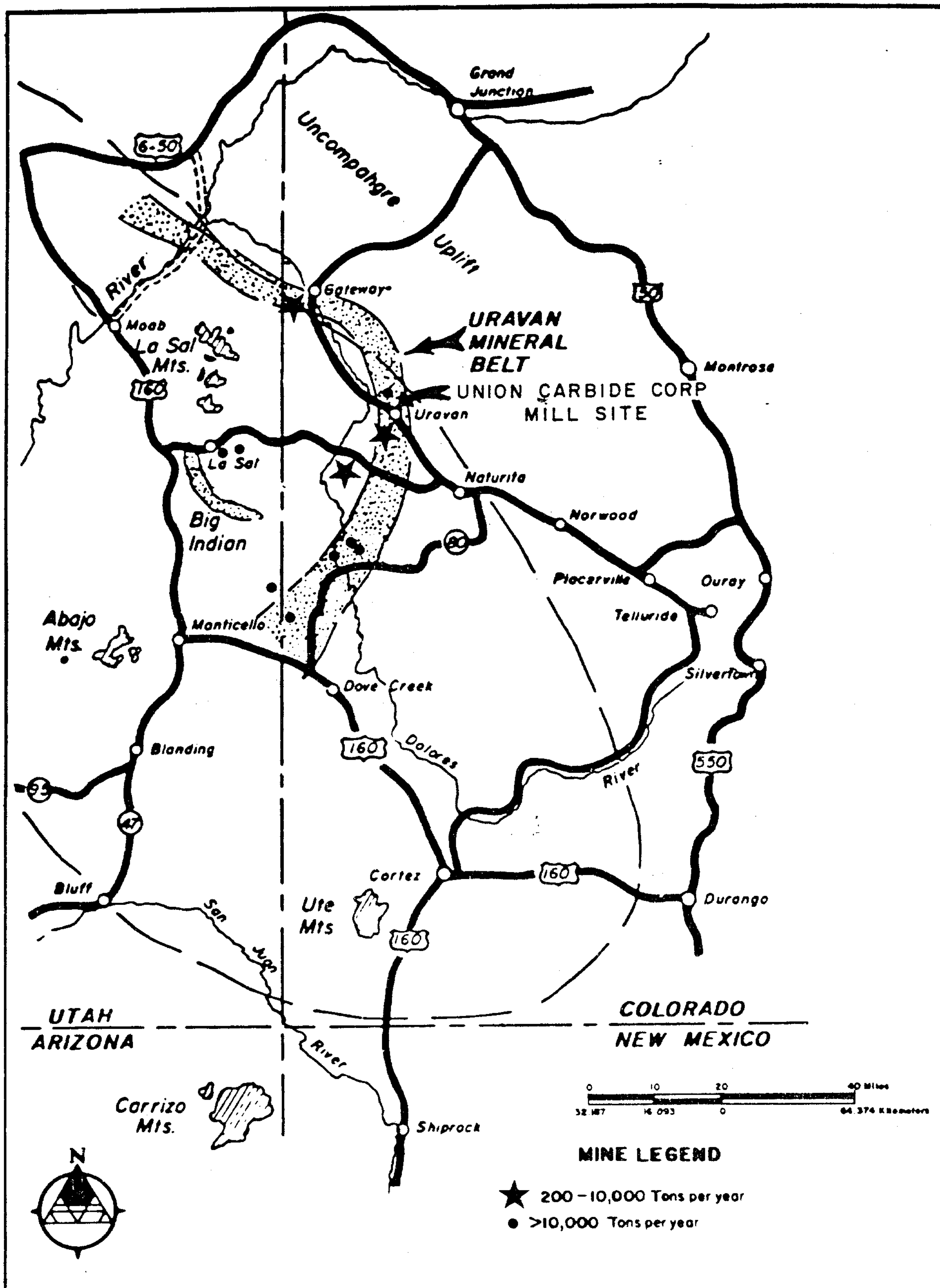
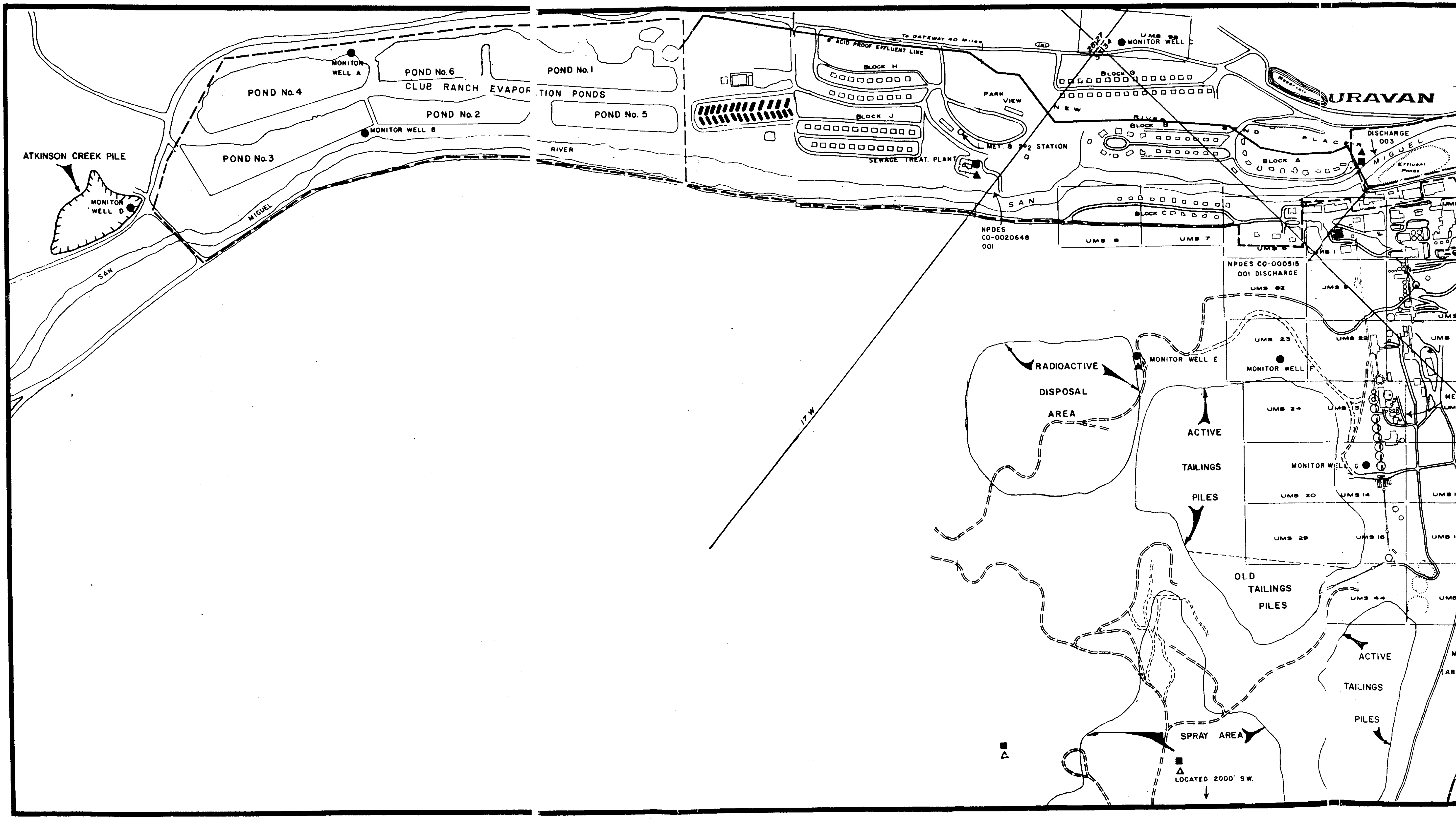


Figure 1. Location Map: Union Carbide Corporation, Uravan, Colorado



ATKINSON CREEK PILE
MONITOR WELL D
MONITOR WELL A
MONITOR WELL B
POND No.4
POND No.6
POND No.1
CLUB RANCH EVAPORATION PONDS
POND No.2
POND No.5
POND No.3
SAN MIGUEL RIVER
6" ACID PROOF EFFLUENT LINE
To GATEWAY 40 Miles
BLOCK H
BLOCK J
BLOCK G
BLOCK B
BLOCK A
BLOCK C
PARK VIEW
MET. & SO_2 STATION
SEWAGE TREAT. PLANT
NPDES CO-0020648 001
UMS 55 MONITOR WELL C
URAVAN
DISCHARGE 003
Effluent Ponds
Reservoir
NEW
RIVER
BEND
PLACER
UMS 8
UMS 7
UMS 6
UMS 1
NPDES CO-000515 001 DISCHARGE
UMS 82
UMS 23
UMS 22
MONITOR WELL E
MONITOR WELL F
RADIOACTIVE DISPOSAL AREA
ACTIVE TAILINGS PILES
UMS 24
UMS 15
MONITOR WELL G
UMS 20
UMS 14
UMS 29
UMS 16
OLD TAILINGS PILES
UMS 44
ACTIVE TAILINGS PILES
SPRAY AREA
LOCATED 2000' S.W.
17 W

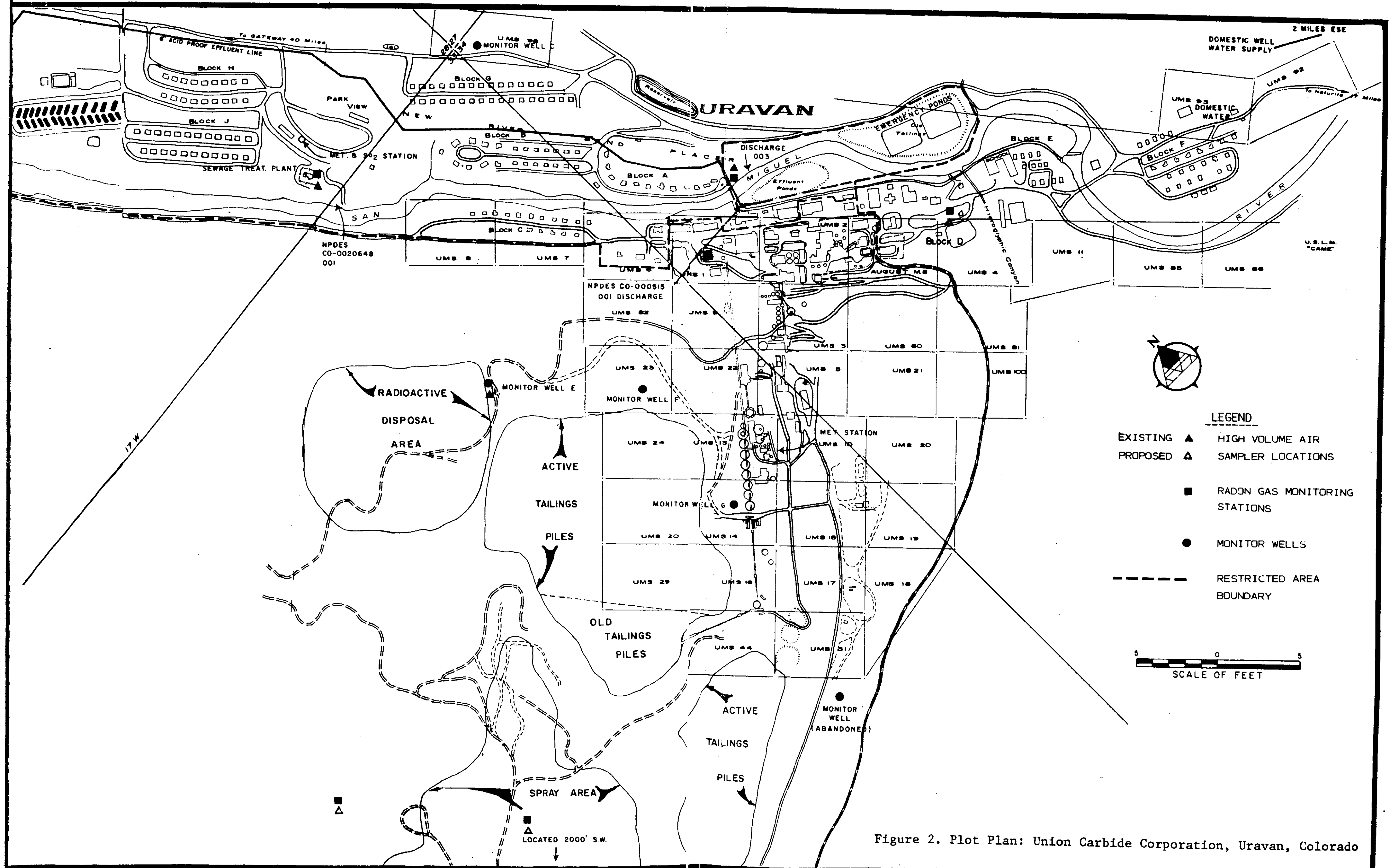


Figure 2. Plot Plan: Union Carbide Corporation, Uravan, Colorado

DRAWING COPIED FROM DAMES & MOORE PLATE, FURNISHED BY UNION CARBIDE CORP.

SITE REPORT: ANACONDA MINERALS COMPANY
Grants, New Mexico

INTRODUCTION

The Anaconda Bluewater mill, located just to the north of Bluewater, New Mexico, will be closed down on March 31, 1982, and put in a "mothballed condition." Anaconda is in the process of relicensing the mill, and if a buyer can be found the mill will be sold. In this event, at some later date, uranium milling on this site could be undertaken once again by some other company. However, in any event, the present tailings pond will be permanently closed down in accordance with the regulations and requirements of the Environmental Improvement Division (EID) of the State of New Mexico.

The mill was originally licensed under AEC License Number SUA-647. This license has an expiration date of February 29, 1976. Relicensing documentation was filed before the expiration date and the licensing period was extended pending review of the submitted documents. New studies and new documents have been resubmitted under the extended license and are undergoing review by the New Mexico Environmental Improvement Division.

Anaconda did not prepare a report on commingled tailings for the American Mining Congress (AMC) so no single report was available for GJAO study. However, Anaconda has furnished the maps and other data requested by GJAO representatives.

BACKGROUND AND HISTORY

OWNERSHIP

The southern boundary of the millsite is immediately to the north of and parallel with the main line of the Santa Fe Railroad and Interstate 40. The site is owned by Anaconda Minerals Company, an operating division of ARCO, and covers approximately 5100 acres (8 square miles). The Bluewater mill has provision for both rail and truck haulage of ore shipments. The millsite contains all of the tailings ponds, the evaporation ponds, the mill and all appurtenant structures, and the Anaconda townsite that provides housing for some employees.

PRODUCTION HISTORY

The original discovery of uranium ore in the Grants, New Mexico, area was made in 1950. Since then, the so-called "Grants Mineral Belt" has developed into the premiere uranium-producing area of the United States. Anaconda was one of the original exploring companies, and it started the first mill in the area in 1953.

The initial AEC contract, AT(05-1)-550, for the purchase of uranium at a negotiated price was signed with Anaconda in 1952. Anaconda operated a buying station for the AEC at the Bluewater in 1952 and 1953.

The concentrate delivered under contract to the AEC is as follows [Department of Energy (DOE) figures]:

Contract No.	Period (FY)	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-550	1954-1958	17,191,109	$10.18
AT(05-1)-773	1959-1971	22,458,528	7.88
		39,649,637[a]	$ 8.88 (average)

[a]This compares with the Anaconda figure of about 39,600,000. The total pounds produced during these periods was 45,014,024.

The first mill constructed on the Bluewater millsite was a carbonate-leach plant, built at the request of the AEC, according to Anaconda. This mill came on stream in October 1953 and treated 300 tons per day of ore produced by nearby mines in the Todilto Limestone and Poison Canyon Sandstone. In March 1955, the mill was expanded to a capacity of 1200 tons per day.

In December 1955, an acid-leach mill with nominal capacity of 2000 tons per day came on line. This mill was designed primarily to treat sandstone ore from the Jackpile Mine, discovered by Anaconda in 1951 a few miles north of Laguna, New Mexico. The ore was transported to the mill by rail, a distance of approximately 50 miles. A 50-ton sulfuric acid plant constructed at the millsite manufactured the acid for processing the ore.

Anaconda operated both the carbonate and acid mills concurrently until May 1959 when the carbonate mill was shut down permanently.

Milling was continued in the acid mill at a rate of 1600 to 1800 tons per day during the 1956-1970 AEC contract period, and the mill recovery of uranium ore was over 90 percent. Ore was produced mainly from the Jackpile and Paguate open-pit mines.

In February 1971, Anaconda received a license amendment that permitted expansion of mill capacity to 4000 tons per day. During the years 1956 to 1979, the grade of ore mined for feed to the acid mill ranged between 0.15 and 0.60 percent U_3O_8. Until 1978, the average grade of ore milled generally was within a range of 0.25 to 0.35 percent U_3O_8.

In January 1978, the nominal mill capacity was increased to 6000 tons per day, and currently (January 1982), the mill is operating at a licensed rate of 6600 tons per day. The ore fed to process grades between 0.06 and 0.07 percent

U_3O_8, and recovery is over 80 percent. Millfeed is ore from low-grade stockpiles at the Jackpile and Paguate mines and production from the NJ45, P13, and P10 underground mines in the Jackpile-Paguate area. Through 1981, Anaconda has processed more than 23,500,000 tons of ore.

The mill will be shut down during February 1982 and mothballed by March 31, 1982.

No byproducts have been produced and no mine water has been processed. No tailings have been reprocessed and there are no plans to reprocess in the future.

PROCESS DESCRIPTION

The original mill constructed by Anaconda was a carbonate-leach plant designed to process the high-lime ore from the Todilto Limestone. This mill began operations in 1953 at a rate of 300 tons per day, but was expanded to 1200 tons per day in 1955 with the addition of increased grinding and filtration capacity. Both limestone ore as well as sandstone ores from the Morrison Formation were treated in this enlarged plant. Ore was ground in recirculated carbonate solutions, and leached at high temperature and elevated pressure for 10 hours. Potassium permanganate was added as an oxidant and calcined magnesite was added to help absorb organics. Fine grinding was essential to free the uranium in the limestone ore. The pulps were flocculated, filtered, and washed on several stages of drum filters. Caustic soda was added and concentrate precipitated by heating with steam.

Detailed information on the water chemistry of these carbonate tailings is not available, but the pH was reported to be as high as 11.2.

The original 2000-ton-per-day acid-leach mill began operation in December 1955, and, until May 1959 when the carbonate-leach mill was closed down, both mills were in operation. This acid plant had two leaching circuits; the series flow of slurry through the tanks had a residence time of about 19 hours in each circuit. Sulfuric acid was the leaching agent and manganese dioxide was added as an oxidant. The final pH was 1.4 to 1.5. A resin-in-pulp (RIP) ion-exchange circuit was used to collect the uranium from solution. Originally the uranium was removed from the resin by nitrate elution, but, due to contamination of ground water by nitrates, a process using chloride elution was initiated in 1957. Magnesium oxide was used to precipitate the uranium. After washing and filtering, the concentrate was dried by heating and then packaged in drums for shipment. The grade of concentrate was 87 percent U_3O_8.

In February 1971, the mill license was amended to increase capacity to 4000 tons per day.

In November 1978, a major expansion and process modification was completed, resulting in an increase in capacity to over 6000 tons per day. This expansion involved a new semiautogenous grinding section, and initiation of a solvent extraction and new precipitation section to replace the RIP section. The present mill utilizes one leaching circuit. The pulp slurry is 55 percent solids, to which sulfuric acid and an oxidant, sodium chlorate, are added.

The solution is heated to 140°F. The pH at this stage is 0.9. The slurry passes through a series of Enviroclear thickeners and then to the solvent extraction circuit. The organic solvent used is a mixture of amine, isodecanol, and kerosene. This organic is moved countercurrently to increase its load of uranium. The organic is then pumped to the stripping circuit where uranium is removed by use of ammonium chloride stripping solution. Air and ammonia are passed through the solution to precipitate uranium as ammonium diuranate. The precipitate is dried and calcined, then packaged in drums. The mill recovery is over 80 percent for the 0.06-0.07 percent U_3O_8 grade of ore being processed at present.

The present tailings disposal area would have been closed in the near future because of constraints on storage capacity. Anaconda was evaluating establishment of below-surface storage by digging large pits in an area east of the Main Pond and using the excavated earth to cover the Main Pond.

SITE DETAIL

LOCATION

The Anaconda mill and tailings ponds are located near the village of Bluewater, New Mexico (Figure 1). The millsite is situated just to the north of the main line of the Santa Fe Railroad and U.S. Highway I-40. Albuquerque is 90 miles to the east on Highway 40. The Anaconda property is mainly in Sections 7, 8, 17, 18, 19, and 30, T. 12 N., R. 10 W., and Sections 12, 13, 23, 24, and 25, T. 12 N, R. 11 W. The area of the site is approximately 5100 acres. The property is irregular in shape; it has maximum dimensions of 4 miles in a north-south direction and 3 miles in an east-west direction. The southwestern boundary of the site also is the right-of-way of the Santa Fe Railroad. The nearest town, Grants, with a population of approximately 10,500, is 11 miles to the southeast.

TOPOGRAPHY

The mill is situated at about 6600 feet elevation in the western portion of the Bluewater Valley, which is characterized by an undulating, relatively level surface with gentle swales and small rounded hills. This northwesterly trending valley is on the northern slope of the Zuni Mountains, which define the southern margin of the San Juan Basin. Cliffs of the Dakota Formation limit the valley on the north. The area is underlain by red beds of the Chinle Formation. The Rio San Jose is the main drainage feature, which courses across the valley in a northwest to southeast direction. Some farming is done in the valley, but it is on a small scale and mainly for hay and alfalfa.

CURRENT CONDITIONS OF TAILINGS

Figure 2, a map furnished by Anaconda, shows the location of the Bluewater mill, the Main Tailings Pond, the evaporation ponds, the North Arid Area tailings, the Carbonate Area tailings, and the property boundary.

There are three tailings piles on the millsite. The first tailings were produced from the carbonate mill. The carbonate tailings were initially deposited in an area immediately to the northeast of the mill, in a separate flat-lying pile covering approximately 47 acres. This inactive pile has been covered with soil to an average depth of 30 inches. The cover was excavated from an area adjacent to and east of the pile. Other carbonate tailings were emplaced in the southern part of what is now the active Main Pond for acid tailings. The actual area of carbonate tailings underlying this pond is unknown, but an area designated as "approximate area of covered carbonate tailings" on the map furnished by Anaconda indicates that the buried carbonate tailings area is approximately 60 acres. Emplacement of all tailings from the carbonate mill was stopped in May 1959. The tailings in the Carbonate Area and the carbonate area underlying the Main Pond were produced under the AEC contract.

A second tailings pile, the North Area Acid Pile, situated immediately northwest of the Main Pond, was also produced under the AEC contract. This area, which is separate from the Main Pond, covers 24 acres. The North Area Acid pile also has been covered with about 30 inches of soil.

The Main Pond is by far the largest accumulation of tailings. This tailings impoundment area of 270 acres was put into operation in 1956, and has been active ever since. The dam is constructed of natural soils and alluvium occurring on the site. All of the material in the dam is well compacted to form a stable structure. The mill tailings slurry, which contains 42 percent solids, is discharged along the southern part of the dam. The dam is over 60 feet high at the south end and over 20 feet high at the north end. The phreatic surface and seepage are controlled by both horizontal and chimney drains built into the dam. The compacted dam prevents windblowing of material from the sides of the structure, and the natural cementing action of sulfate efflorescence, which forms on the surface of the tailings, cements the sand grains and thereby reduces wind erosion. The tailings are well maintained and monitored continuously by Anaconda personnel.

QUANTITIES

The following table summarizes the tons and areas of tailings in the three disposal areas. The figures used in the table are those furnished by Anaconda, because the DOE records do not contain information on the distribution of tons tailings among the three tailings areas. The figures for total tonnages are in general agreement with the DOE figures.

Tailings Pile	Tons Through 12/31/70		Acres of Tailings, 1981	
	AEC	Total	AEC	Total
Main Pond	8,197,591	9,297,591	Commingled[a]	270
Carbonate Area	584,184	584,184	47[b]	47
North Area Acid	180,849	180,849	24[b]	24
Totals	8,962,624	10,062,624[c]	71	341

[a]This pond contains 736,889 tons of carbonate tailings, produced under the AEC contract, which underlie the acid tailings. The area of the carbonate tailings is approximately 68 acres. For practical purposes, all tailings in the Main Pond are "commingled tailings."

[b]Separate piles of tailings produced under the AEC contract, not commingled.

[c]1,100,000 tons of this total were produced under commercial contracts, according to Anaconda.

The DOE figure for the tailings produced under the AEC contract is 8,836,679 tons, which is 125,945 tons less than the corresponding Anaconda figure. The DOE figure was obtained by deriving a ratio of the pounds U_3O_8 sold to AEC to the total pounds produced during the AEC contract period, and applying this factor to the total tons of ore processed during the period. The total tons of ore processed, according to DOE, were 10,032,560, which is 30,064 tons less than the corresponding Anaconda figure. Regarding the tons of ore processed for the AEC contract, the difference is less than 2 percent; in the case of total tons processed, the difference is less than 1 percent.

The total tailings on the site as of the end of December 1981 are approximately 23,586,000 tons.

TAILINGS MANAGEMENT HISTORY

The first tailings emplaced on the site, in 1953, were produced by the original carbonate mill that was operated at a 300-ton-per-day rate. These tailings were deposited east of the mill in a shallow dammed emplacement. This Carbonate Area pond was active until about mid-year 1958. During this period, carbonate tailings disposal alternated between the Carbonate Area and the Main Pond that was first used for tailings disposal in 1956. In May 1959, the carbonate mill was shut down, and the last of the carbonate tailings was sent to the Main Pond.

In December 1955, the 2000-ton-per-day acid-leach plant was put into operation and, at start-up, a small amount of acid tailings was deposited in the Carbonate Area. However, from January 1956 and continuing until present, all of the tailings produced by the acid mill were deposited in the Main Pond with one minor exception. This exception was during the January to May 1958 period when approximately 181,000 tons of tailings were deposited in the North Area Acid Pond.

The tailings management plan, at present, in the large Main Pond is essentially the same as was originally planned. The south end of this pond has been constructed by the upstream method and the north end (the low end) by downstream construction. The configuration and buildup of the tailings fans are controlled by moving the slurry discharge lines from place to place along the southern part of the dam, and by dikes that control the direction of tailings flow down the slope of the pile (see Figure 3, a photo furnished by Anaconda). A decant-liquid barge is situated at the extreme north end of the Main Pond. The liquid recycled to the mill is pumped from this floating platform.

Originally the liquid tailings were disposed of by evaporation in the large Main Pond. However, in 1960, Anaconda was granted a license amendment that permitted use of an injection well for disposal of the decant liquid from the Pond. This waste liquid was discharged into the Meseta Blanca member of the Yeso Formation (Permian). However, the environmental regulations of the State of New Mexico that became effective in December 1977 forced the closure of this disposal well. The average disposal rate over the life of the injection well was 300 gpm. The closure of this well led to construction of evaporation ponds by Anaconda.

From December 1977 until February 1978, all of the liquid waste was retained in the Main Pond. The Phase I evaporation ponds were put into use during February 1977, the Phase II in January 1980, and the Phase III in December 1980. The total area of the seven evaporation ponds is 292 acres. The rate of evaporation is approximately 5 feet per year. Since the evaporation ponds went into use, the area of water in the Main Pond has been reduced from about 121 acres to 5 or 10 acres. All of the evaporation ponds are lined with either PVC plastic or Hypalon sheeting so seepage is minimized.

Anaconda is presently monitoring the tailings areas through use of check stations, wells, and drill holes, and the site is photographed from the air monthly. Periodically, Anaconda sends reports to the Environmental Improvement Division (EID) of the State of New Mexico and to the New Mexico State Engineer. EID monitors environmental aspects of radiation, air, and water; the State Engineer monitors stability of the dam and impounded tailings.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The area is still predominantly rural in character. There are no clusters of population within the immediate vicinity of the mill, with the exception of the Anaconda townsite, which is on the millsite. All of the 250 inhabitants are Anaconda employees and their families. Bluewater, the nearest village (Figure 1) which is located approximately 1.5 miles east of the mill, has a population of 300, and the village of Milan, which is located approximately 8 miles southeast of the site on Interstate 40, has a population of 2600. The largest town, Grants, is located approximately 11 miles southeast of the site and has a population of 10,500. Due to the current poor uranium market, the entire region is losing population as mines and mills are shut down.

WATER

The only stream in the vicinity of the Anaconda site is the Rio San Jose that courses through the Bluewater Valley in a northwest to southeast direction. This small stream, which is perennial for only a portion of its length, crosses the extreme southern part of the millsite. It poses no potential flood problems to the tailings areas.

The ground-water hydrology of the Bluewater millsite is complex because of complicated geologic relationships, including faulting and folding, and the interconnection of the two regional aquifers, the San Andres Limestone-Glorieta Sandstone and the Alluvium. A number of formations underlie the site. In order of age from oldest to youngest, they are: Yeso (Permian), Glorieta Sandstone and San Andres Limestone (Permian), Chinle (Triassic), Older Alluvium (Tertiary), and Malpais Volcanics and Recent Alluvium (Quaternary).

The Main Pond is in a topographic depression in the Malpais Volcanics north of the mill. The northeastern part and western half of the Pond are underlain by the volcanics, which are superjacent to the Older Alluvium. The southeastern part is underlain by the Glorieta Sandstone. An east-west vertical fault passes under the south side of the Main Pond, and an intersecting vertical north-south fault passes under the central part of the Pond. Folding of the older strata also occurs in the vicinity of the Pond. The juxtaposition of the San Andres-Glorieta and the Chinle resulting from the faulting and the complex hydraulic relationships between the Older Alluvium and the San Andres-Glorieta complicate the subsurface flow of ground water in the vicinity of the Main Pond.

Anaconda estimates current seepage from the Main Pond to be 30 to 50 gpm; between 600 and 800 gpm of decant liquid is recycled back to the mill and the remainder is sent to evaporation ponds. The pH of the liquid tails is 0.9 to 1.1. The total amount of liquid required for the 6600-ton-per-day rate of milling is 1800 gpm. Anaconda attributes the low seepage rate to the small area, 5 to 10 acres, of liquid near being maintained in the decant pond. In general, flow of ground water down hydraulic gradient from the Main Pond is to the east and southeast.

The low pH of the seepage is buffered by the natural alkalinity of the soils and ground water, resulting in the restoration of the normal pH of 7 or 8 within relatively short distances from the Pond. The heavy elements in the seepage, including the radionuclides, are usually precipitated within 10 or 20 feet after entering the natural subsurface environment. The seepage from the Ponds exceeds the EID standards for TDS, chloride, and sulfate, but, according to Anaconda, there are no serious problems with ground-water contamination.

The wells serving the municipal water systems in the city of Grants and the villages of Milan and Bluewater have not been affected by the tailings water seepage from the Main Pond. Because of favorable locations with respect to regional ground-water flow patterns, it is highly unlikely that these wells will be affected in the future by seepage from the Main Pond.

AIR

The area is in the climatological subdivision of New Mexico called the "southwest mountains." The dominant characteristics are low precipitation, sunny days, low humidity, and moderate average temperatures with large fluctuations in the diurnal and annual extremes. The mill is in the Bluewater Valley where the predominant wind directions are westerly and tend to be channeled through the valley by the Zuni Uplift to the south and escarpments of northerly dipping Cretaceous Formations to the north. Wind gusts commonly exceed 50 miles per hour. The relative humidity ranges from 65 percent at sunrise to 30 percent by afternoon, but commonly may be less than 15 percent. The mean daily temperature is 41°F, the mean maximum is 65°F, and the mean daily average is 54°F. Annual precipitation averages approximately 8.8 inches per year. The maximum recorded was 13.5 inches in 1956. August is the wettest month with an average of 2.2 inches. Most of the precipitation falls as rain, but some snow falls in the winter months. The area receives 75 percent sunshine in the winter and 80 percent in the summer.

Surveys and calculations indicate that no individual predicted annual radiation dose rate will exceed the 25-millirem-per-year limit set by the Environmental Protection Agency (EPA) for population clusters. This holds for the Anaconda townsite and areas off the millsite as well. Anaconda has established air monitoring stations for radioactive particulates around the site, and results are reported quarterly to the EID.

SURFACE CONTAMINATION

Due to the stable nature of the compacted soil dam containing the commingled tailings, there have been only minor problems with windblown tailings from the Main Pond. As the inactive Carbonate Area and North Area Acid tailings have a soil cover, the blowing there is eliminated. As mentioned previously, the tendency of the surface of the Main Pond tailings pile to be cemented by the precipitation of interstitial sulfates also reduces the amount of windblown material.

DISCUSSION OF VIABLE STABILIZATION PLANS

Anaconda is preparing a final stabilization plan for submission to the EID in the near future. The EID regulations require disposal of liquids standing, inactive waste-retention systems, and stabilization of waste retention systems "as soon as practicable" after inactivation of the system.

Anaconda plans are to stabilize the tailings on the site; material suitable for covering the tailings can be obtained on the site. Discussion with Anaconda personnel indicated that plans would be based on criteria and standards in effect at the time of submission of the decommissioning and reclamation plan.

Anaconda personnel indicated that any cost estimate at the time would be preliminary; also, that much more study will be necessary to better define the various cost factors and parameters influencing cost. Anaconda indicated that there would be a large difference in costs depending on which regulations apply to stabilization and reclamation.

Anaconda has already paid $1 million into the New Mexico Continued Care Fund as required by the EID regulations. In addition, Anaconda recognizes that the EID regulations also dictate eventual transfer of ownership of the property to the state or Federal government after stipulated requirements are met.

In a letter dated December 31, 1981, Anaconda provided the following information regarding possible costs:

> It is very difficult to estimate the cost of decommissioning but a preliminary estimate is approximately $60 million for both reclamation and decommissioning of the mill based upon the presently available NRC criteria. This is only an estimate and would be subject to change as regulatory requirements change.

DISCUSSION OF PROPOSED COST-SHARING PLANS

At the meeting with Anaconda on December 8, 1981, some discussions centered on what the basis for Government participation should be. Some of the questions that were raised, but unresolved, were:

- Should the evaporation ponds be an Anaconda responsibility?
- Should the Mill decommissioning cost be split between Anaconda and the Government on the basis of AEC contract tons to total tons processed?
- Should the Carbonate and North Area Acid tailings be the Government's responsibility?
- Should the Main Pond costs be shared on the basis of AEC contract tons to total tons processed?

No agreement on a cost-sharing plan was reached.

REFERENCES

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Vol. II: "Geology and Geoseismicity," Dames and Moore, April 1981.
Vol. III: "Regional Ground-Water Hydrology and Water Chemistry, Grants-Bluewater Area, Valencia County, New Mexico," Hydro Search, Inc., June 1981.
Vol. IV: "Ground-water Hydrology in the Vicinity of Anaconda Copper Company's Bluewater Mill, Valencia County, New Mexico," Hydro Search, Inc., July 1981.
Vol. V: "Mill and Mill Waste Effluent System Description," Science Applications, Inc., July 1981.
Vol. VI: "Radiological Impacts on Operations," Western Radiation Consultants, Inc., April 1981.

"State of New Mexico Radiation Protection Regulations," Environmental Improvement Division, Radiation Protection Bureau, April 1980 and October 1981.

"Uranium Development in the San Juan Basin Region - Final Report," U.S. Department of Interior, Fall 1980.

FIGURES

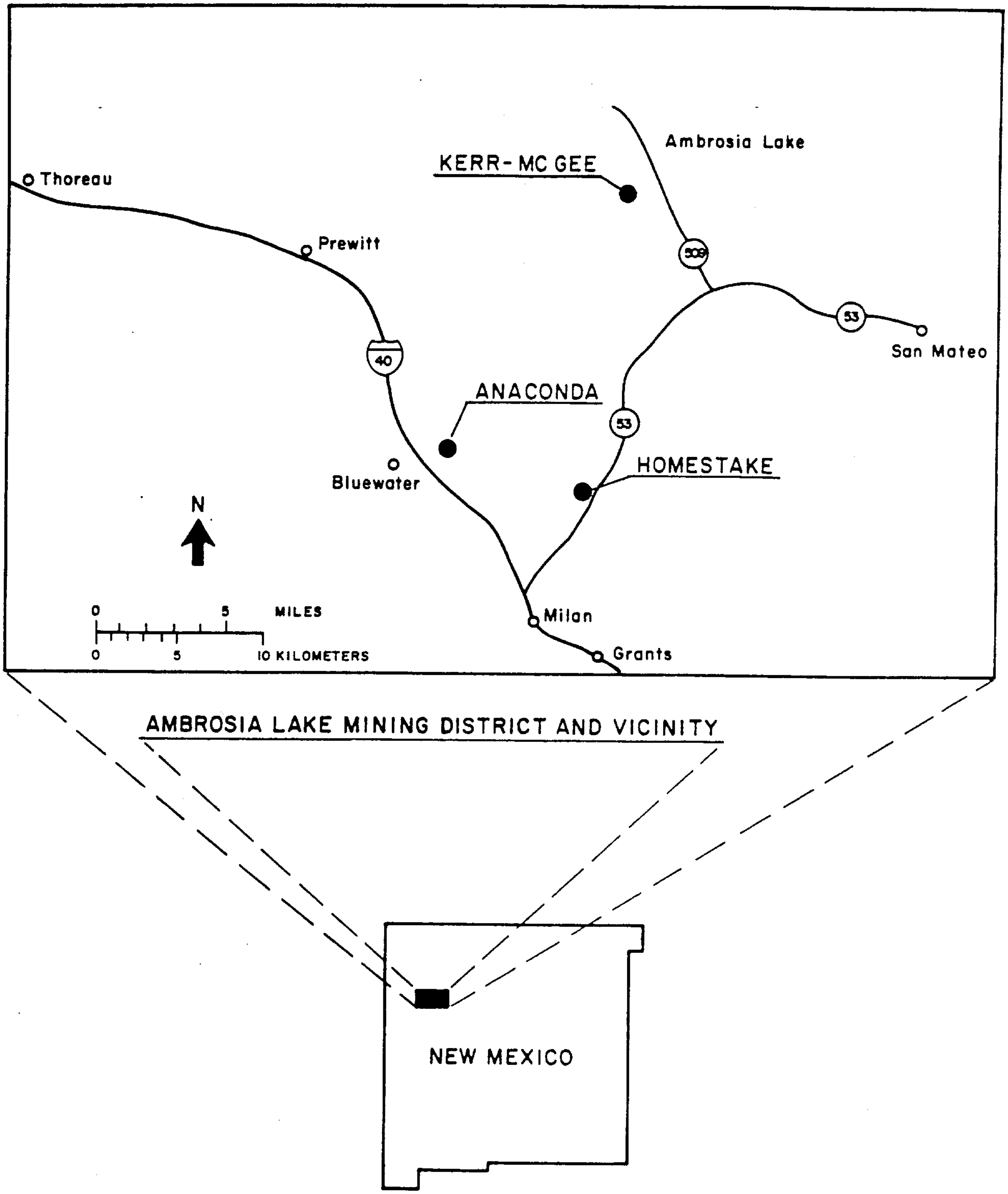

Figure 1. Location Map: Anaconda Millsite, Grants, New Mexico

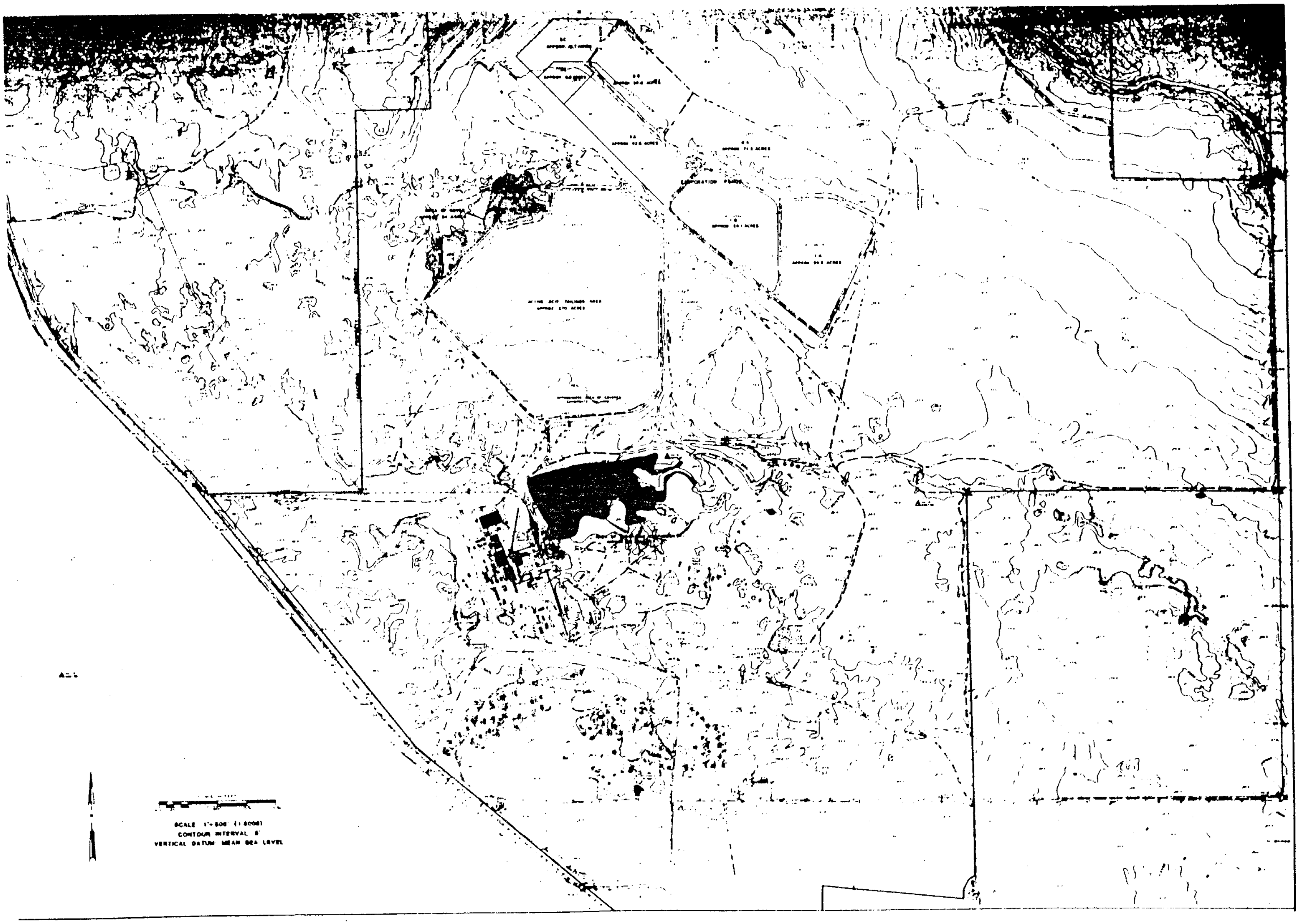

Figure 2. Plan View of the Anaconda Millsite and Tailings Ponds

SITE REPORT: HOMESTAKE MINING COMPANY
Grants, New Mexico

INTRODUCTION

The Homestake mill is located about 6 miles north of Milan, New Mexico, on State Highway 53 (Figure 1). Milan is 80 miles west of Albuquerque on Interstate 40.

Information in this report was obtained mainly from Homestake personnel and from the reports and other data furnished by Homestake. The DOE Grand Junction Area Office (GJAO) files were utilized as needed for production data. Other information sources are listed under references.

Homestake furnished two reports entitled "Commingled Tailings - A Report to the Department of Energy" and "Groundwater Discharge Plan for Homestake's Mill Near Milan, New Mexico" to the Grand Junction Area Office, U.S. Department of Energy.

Homestake submitted the following information regarding its mill license:

> In 1974, the Governor of New Mexico and the United States Atomic Energy Commission entered into an agreement pursuant to provisions of the Atomic Energy Act, as amended, providing for the discontinuance of AEC regulatory authority over uranium mills in New Mexico. Uranium mills in New Mexico are licensed under authority of the New Mexico Radiation Protect Act (74-3-1), et seq. N.M.S.A. 1978). The regulations for uranium mills are adopted by the New Mexico Environmental Improvement Board, with the advice and consent of the New Mexico Radiation Technical Advisory Council. The New Mexico Environmental Improvement Division is the agency which administers the regulations. Section 3-430 of the Radiation Protection Regulations of the NMEIB provides that if a uranium mill applicant files a renewal application 30 days before the expiration of the license, the license does not expire until the application has been finally determined by the NMEID. Homestake filed a renewal application, which is now pending. The application is expected to be supplemented in March or April 1982, to include additional information and to address certain subjects occasioned by recent changes in the regulations. New Mexico regulates both the mill proper and tailings.
>
> Recently, the NRC asserted it, not New Mexico, regulated mill tailings (but not mills) in New Mexico. NRC purported to issue a general license to Homestake and other New Mexico mills. Homestake, Kerr-McGee Nuclear, and United Nuclear sought review of the NRC action in the United States Court of Appeals for the District of Columbia. NRC, in response to federal legislation, has now withdrawn the order of which the companies complained.

The Homestake mill is operating under the former AEC Source Material License Number SUA-708, and is currently in the relicensing process with the State of New Mexico, which is an Agreement State.

BACKGROUND AND HISTORY

OWNERSHIP

The Homestake mill is situated on Highway 53 in Section 26, T. 12 N., R. 10 W.; this site and a half-mile buffer zone surrounding the mill area are owned by Homestake Mining Company. The millsite contains the two tailings piles, the active Homestake Mining Company mill, and the inactive mill formerly operated by Homestake-New Mexico Partners (HNMP).

The Homestake Mining Company milling operations started as two partnerships, each one with Homestake as the managing partner. Homestake-Sapin Partners (HSP) was the larger partnership; HNMP constructed a mill with nominal capacity of 750 tons per day. On November 9, 1961, the partnerships merged with HSP being the survivor.

In April 1968, Homestake-Sapin Partners became United Nuclear-Homestake Partners; in March 1981, Homestake purchased United Nuclear Corporation's share and the operation became Homestake Mining Company - Grants.

PRODUCTION HISTORY

Homestake was among the first companies to develop and mine ores from the nearby and important Ambrosia Lake area that was discovered by drilling in the spring of 1955. The large uranium deposits are in sandstones of the Westwater Canyon Member of the Morrison Formation. All of the mines are underground with shaft access.

Homestake-New Mexico Partners

The initial contract, AT(05-1)-724, between the USAEC and Homestake-New Mexico Partners was signed on December 20, 1956. A second contract, AT(05-1)-905, was signed on November 9, 1961, for delivery of additional pounds U_3O_8. This mill processed ores from the Partnership's underground mines at Ambrosia Lake. The mill was shut down in January 1962, but since then the Homestake-Sapin mill has utilized a portion of the Homestake-New Mexico mill's circuitry to increase capacity.

The following table abstracts the AEC-contracted production record for the HNMP mill [Department of Energy (DOE) records]:

Contract	Period	U_3O_8 (lbs.)	Average Price ($/lb.)
AT(05-1)-724	FY 1958 - FY 1962	4,260,000	$8.54
AT(05-1)-905	FY 1962	736,753[a]	8.00
Total		4,996,753[b]	$8.45 (average)

[a]This is a Homestake estimate. The number cannot be checked in DOE files, because these files do not separate the amount of ore processed and concentrate produced by each mill under the contract, AT(05-1)-905, during the time that both mills were operating.

[b]This total agrees with the Homestake figures in the reports submitted to the Department of Energy.

The mill commenced operations in February 1958. During its life, the mill processed ore that averaged approximately 0.22 percent U_3O_8. Mill recovery exceeded 90 percent. All of the concentrate produced by this mill was purchased by the AEC, and all tailings were placed in a single pile adjacent to the mill.

This mill did not produce byproducts; no ore was toll-milled; no tailings were reprocessed; and no tailings have been removed from the site.

Homestake-Sapin Partners

The initial contract, AT(05-1)-721, between the USAEC and Homestake-Sapin Partners was signed on April 23, 1957. Two additional contracts, AT(05-1)-789 and AT(05-1)-905, were signed on July 27, 1960, and November 9, 1961, respectively. In addition, United Nuclear Corporation assigned AT(05-1)-737 to the Homestake Partnership following the United Nuclear Corporation acquisition of the Phillips uranium mill. Contract AT(05-1)-737 was signed on July 17, 1957.

The following table abstracts the AEC-contracted production record for the HSP Mill (Department of Energy records):

Contract	Period	U_3O_8 (lbs.)	Average Price ($/lb.)
AT(05-1)-721	FY 1959 - FY 1960	2,779,374	$8.59
AT(05-1)-789	FY 1960 - FY 1962	3,216,925	8.00
AT(05-1)-905	FY 1962 - FY 1970	19,218,747	7.78
AT(05-1)-737	FY 1963 - FY 1971	12,020,378	7.85
Totals		37,255,424[a]	$7.88

[a]The corresponding figure in the Homestake report to DOE is 37,060,278 pounds U_3O_8. This is 195,146 pounds less than the DOE figure. The total pounds U_3O_8 produced during the AEC contract period was 41,358,447.

The mill commenced operations in May 1958. The average grade of ore processed during the AEC contract period was 0.175 percent U_3O_8, and mill recovery was between 92 and 95 percent.

According to Homestake, as of November 1, 1981, the mill had processed a total of 9,918,770 tons of ore for commercial sale. All of the tailings produced since the mill started operations are in a single large pile near the mill. The tailings produced for the AEC contracts and for the commercial market are commingled.

This mill commenced operations in May 1958 with a nominal capacity of 1650 tons per day, but with the addition of the adjacent Homestake-New Mexico Partners facilities and subsequent improvements the mill was rated at 3500 tons per day. The ore sources over the years have been Homestake-Sapin Partners and the United Nuclear-Homestake Partners (UNHP) underground mines in the Ambrosia Lake area, the United Nuclear Corporation underground mines, and custom shippers. During the 1971-1980 period, when all the production was sold on the commercial market, the average amount of ore processed was approximately 2100 tons per day and, during much of this period, the millfeed graded approximately 0.20 percent U_3O_8.

In December 1981, the milling rate was between 1500 and 1600 tons per day, with a working schedule of 10 days on and 4 days off every 2 weeks. This is an average rate of approximately 400,000 tons per year.

Homestake plans to reduce capacity to between 1100 and 1200 tons per day in the near future; this will be a rate of 300,000 tons per year. The ore being processed ranges in grade from 0.05 to 0.30 percent U_3O_8 and averages approximately 0.15 percent U_3O_8. Production is from the Section 23 and Section 25 mines at Ambrosia Lake and from Homestake's Pitch Mine in Colorado. No toll ore or custom ore is being milled at present. Current plans are to continue milling at least through 1986, but at a reduced rate of somewhat over 282,000 tons per year.

A small amount of vanadium is produced as a byproduct, but only because it must be removed in processing to prevent contamination of the uranium concentrate. Homestake did not toll mill in the commercial sense during the time the AEC contracts were being fulfilled. Some ore was processed for the United Nuclear partner, but no tolling charge was levied or paid. No tailings have been reprocessed, and there are no plans at present to do so. Homestake has not used tailings for mine backfill, and has not permitted tailings to be removed from the millsite.

PROCESS DESCRIPTION AND MAJOR CHANGES

Homestake-New Mexico Partners Mill

This mill started operations in February 1958 and ceased operations in January 1962. This was a 750-ton-per-day alkaline leach-caustic precipitation mill. The tailings were discharged in a dammed area immediately to the southwest of the mill.

The Homestake mill, which is adjacent to the Homestake-New Mexico Partners mill, still continues to utilize a portion of the HNMP mill, including Pachuca tanks and related mill circuitry. The six drum filters were removed from the HNMP mill and installed in the Homestake-Sapin mill to increase capacity. In 1963, a tailings solution ion-exchange system was added to the Homestake-Sapin circuit and placed in the HNMP mill. In 1971, the ballmill was removed and installed in the Homestake-Sapin mill as a regrind unit.

The metallurgical process in the HNMP mill was similar to the method presently being used at the Homestake mill. As mentioned previously, the grade of ore processed by the HNMP mill averaged 0.22 percent U_3O_8 and mill recovery exceeded 90 percent.

Homestake Mining Company Mill (formerly Homestake-Sapin Mill)

This mill commenced operations in May 1958 with a capacity of 1650 tons per day. The mill processed both limestone and sandstone ores, but the sandstone ore presently constitutes nearly all of the millfeed. The ore grades as mined range from 0.04 to 0.30 percent U_3O_8, so ore lots are selectively crushed.

The mill utilizes an alkaline leach-caustic precipitation process for uranium recovery. With the addition of the grinding facilities and circuitry of the HNMP mill, the capacity of the Homestake mill was increased to 3500 tons per day.

The mill utilizes two parallel circuits in grinding, thickening, and leaching. In the grinding circuit, the ore is ground to about 50 percent minus 200 mesh in a sodium carbonate and sodium bicarbonate mill solution. In the thickening circuit, the slurry is thickened to about 40 percent solids and sent to the leaching circuit.

Extraction takes place in a two-stage circuit where the pH is 11. The first stage is a pressure leach at 60 psi and 200°F leached slurries are pumped to filters where soluble uranium is removed by three stages of countercurrent filtrations. The filtrate is the pregnant solution that is clarified and sent to the precipitation circuit after being heated to 180°F. Caustic soda is used to raise the pH above 12 which precipitates the uranium as sodium diuranate. The primary precipitation of concentrate is followed by processing to remove vanadium and other impurities. This is necessary to upgrade the concentrate to the required specifications for marketing.

After removal of impurities, the uranium is reprecipitated as ammonium diuranate and sulfate containing about 85 percent U_3O_8. The product is roasted and packaged in 55-gallon drums.

The decant solution recycled from the tailings pond is returned to the mill where it is processed in an ion-exchange circuit for uranium removal. This ion-exchange plant treats 1200 gpm of solution and yields a tail of less than 10 ppm U_3O_8.

As mentioned previously, the mill recovery of uranium is between 92 and 95 percent and the grade of ore processed has averaged 0.175 percent U_3O_8.

Heap Leaching, Mine, Mine Water Treatment

Homestake operated a dump-leach operation at its Section 25 mine where between 50,000 and 100,000 tons of material were treated over the life of the operation. This project was started in 1966 and was operated intermittently until 1976 when it was shut down. The uranium product was trucked to the mill for processing. Plans are to clean up this site at the time of mill decommissioning.

Homestake also recovers uranium from mine water, which contains 18 to 20 ppm uranium. An ion-exchange plant treats between 1600 and 1800 gpm of mine water from the Section 23 and Section 25 mines at Ambrosia Lake. The pregnant solution from this operation and a similar operation by United Nuclear at its Section 34 mine are transported by truck 16 miles to the mill for processing. Recovery of uranium from mine water is approximately 95 percent.

Uranium recovered from mine water during the pre-1971 AEC contract period amounted to 372,724 pounds U_3O_8, according to Homestake.

SITE DETAIL

LOCATION

The Homestake mill and tailings ponds are located approximately 6 miles north of the village of Milan, New Mexico, on State Highway 53, the main route to Ambrosia Lake (Figure 1). The Homestake property is a roughly equidimensional area of approximately 1500 acres. The dimension in an east-west direction is approximately 9000 feet and in a north-south direction 8500 feet. The Homestake mill is about 5 miles east of the Anaconda mill. It is in parts of Sections 22, 23, 24, 25, 26, 27, and 35, T. 12 N., R. 10 W.

TOPOGRAPHY

The mill is situated at about 6600 feet elevation in the San Mateo Drainage on alluvial soil. The site is on relatively level ground that slopes gently to the south and west. The valley at this place is bounded on the northwest by Haystack Mountain and on the southeast by Grants Ridge. This area is on the northern slope (Chaco Slope) of the Zuni Mountains, which define the southern margin of the San Juan Basin. The millsite is in the San Mateo drainage.

CURRENT CONDITIONS OF TAILINGS

Figure 2 (furnished by Homestake) shows the location of the Homestake mill, the active tailings pile, the inactive tailings pile, the location of alluvial wells, and the property boundary.

There are two tailings piles on the site, the inactive HNMP pile and the active Homestake pile. The small inactive pile is southwest of the mill and the large active pile is northwest of the mill.

Homestake-New Mexico Partners Inactive Pile

This pile was produced during the 1958 and 1962 period, and all of the uranium produced was sold to the AEC. These tailings are contained within an embankment of earth and soils excavated on the site. The area of tailings is approximately 40 acres. This pile, which contains over 1,200,000 tons, has been covered to a depth of a few feet over about 20 percent of its area with contaminated soils excavated from beneath a tailings spill from the large active pile. In addition, approximately 50 percent of the surface of this pile has been covered with scrap materials discarded from mill operations. This was done to help prevent wind erosion and dusting. Also, Homestake has cooperated with the U.S. Soil Conservation Service to establish a grass cover on this pile. These projects have been effective in reducing wind and rain erosion.

Homestake Active Pile

This pile is by far the larger accumulation of tailings on the site and, as of December 31, 1981, the pile contained approximately 19,922,000 tons (DOE figure).

The tailings pile is in the shape of a large rectangular-base prism that rises above a relatively level ground surface. The base of the pile is approximately 3900 feet long in an east-west direction, is approximately 1900 feet wide, and the pile is between 80 and 85 feet high. It covers approximately 170 acres. The slopes of the sides of the pile are about 2 to 1 at present. There are two disposal cells on top of the pile that are used alternatively for tailings discharge. The east cell contains about 65 percent of the total tailings. The top of the east cell inner disposal area measures about 55 acres and the west cell about 45 acres.

In order to help prevent wind and rain erosion, the sides and upper embankment of the pile are stabilized by spraying with a latex base compound. The cost is about $0.08 per square yard or a total of $70,000 to $90,000 each time the spraying is done. This treatment has been effective in reducing windblowing of tailings. The precipitation on the surface of some of the carbonate compounds used in the milling process also aids in stabilizing the coarser tailings on the upper embankment of the pile.

Homestake complies with requirements of the New Mexico State Engineer's Office regarding stability and construction of the tailings embankment. Piezometers have been installed in both the tailings and underlying natural soil and alluvium to measure the phreatic surface and zones of water saturation. The State Engineer has also required establishment of survey stations on the slopes of the tailings pile to detect any slight horizontal movement or shifting within the pile. The stations are surveyed regularly by high precision methods to ensure continued stability. On a regular basis, reports of monitoring are furnished to the State Engineer. This pile is under constant surveillance by Homestake personnel.

QUANTITIES

Homestake-New Mexico Partners Inactive Pile

This tailings pile was produced in its entirety under the AEC contract; all of the U_3O_8 produced was sold to the AEC. There are no commercial tailings in this pile.

According to Homestake records, this inactive pile contains approximately 1,223,193 tons of tailings and covers 40 acres. The DOE estimate for the quantity of tailings is 1,241,774 tons. This is 18,581 tons larger than the Homestake figure, a difference of less than 2 percent.

Homestake Active Pile

This is a commingled pile. There are no photographs, maps, or cross sections that show the aereal extent or three-dimensional configurations of the tailings as of December 31, 1970. The tailings produced under the AEC contract were deposited in both cells of the tailings impoundment, and are commingled with and overlain by tailings produced for the commercial market. This pile occupies only a slightly larger area today (about 13 percent larger, according to Homestake) than it did at the termination of the AEC contract. The pile has been built up to a total height of between 80 and 85 feet to store the tailings produced since that time.

The area covered by this pile is approximately 170 acres and is listed in the Homestake report as containing 9,759,603 tons of tailings produced under the AEC contracts. This Homestake estimate represents the allocated tons that the UNHP determined to be related to the AEC sales, for the purposes of the financial statements.

The comparable DOE figure for the quantity of tailings produced under the AEC contract is 10,169,449 tons, which is 409,846 tons higher than the 9,759,603 Homestake figure; this is a difference of about 4 percent. The DOE figure was obtained by deriving a ratio of the pounds U_3O_8 sold to the AEC to the total pounds produced during the AEC contract period and applying this factor to the total tons of ore processed during the period. The total tons of ore processed in the AEC contract period, according to DOE, was 11,289,353. This total also includes the ore processed for commercial sales. The comparable Homestake figure is 11,092,526 tons, which is 196,827 tons less, a difference of about 2 percent.

The following table compares the DOE and Homestake estimates for the tons of tailings produced by each mill for the AEC contracts, and shows the areas of both tailings piles.

Tailings Pile	Tons Processed for AEC Through 12/31/70: DOE Estimate	Tons Processed for AEC Through 12/31/70: Homestake Estimate	Acres of Tailings On-Site[a]: 12/31/70	Acres of Tailings On-Site[a]: 12/31/81
HNMP (inactive)	1,241,774	1,223,193	40[b]	40
Homestake (inactive)	10,169,449	9,759,603	commingled[c]	170
Totals	11,411,223	10,982,796		210

[a]Homestake figures.

[b]All tailings were produced under the AEC contract.

[c]According to Homestake, this pile was approximately 13 percent smaller in area on December 31, 1970, than at present.

According to DOE records, the total tons of ore fed to process through December 31, 1981, were 19,922,541. This is the quantity of tailings in the commingled pile. The comparable Homestake figure, making provision for November and December 1981, is 19,744,043. The DOE figure is 178,498 tons higher than the Homestake number; this is a difference of less than 1 percent.

The Homestake ore-reserve base is adequate to permit operations into the 1990-2000 period. However, on the basis of its sales position, Homestake anticipates operating at least to the end of 1986 at an annual rate of 282,540 tons per year fed to process. This rate would indicate a total of over 21,000,000 tons of tailings in the commingled pile by the end of 1986.

TAILINGS MANAGEMENT HISTORY

Homestake-New Mexico Partners

This mill commenced operations in February 1958. The tailings pond is located in SW-1/4, Section 26, T. 12 N., R. 10 W. The tailings pile is situated immediately to the southwest of the mill and is about 700 feet south of Homestake's large active pile. The tailings are impounded inside a dam that was constructed out of compacted natural soils. This compacted dam is 40 feet wide at the base and 10 feet wide at the crest. The pile has a low profile, being only 20 to 25 feet high. The method of impoundment was simple, as the tailings slurry was discharged into the dammed enclosure and the coarser material was spread out with scrapers to maintain proper distribution of the tailings. The tailings slurry from the mill was discharged into the northeastern part of the pond.

Homestake Mining Company

The first tailings in this commingled pile were produced by the original Homestake-Sapin Partners mill at start-up in May 1958. The pile is located on the N-1/2, Section 26, T. 12 N., R. 10 W.

The starter dam for this impoundment area was constructed from natural soils in the area and compacted by earth-moving equipment. This original dam was built up to a height of 10 feet, the bottom width was 25 to 30 feet, and the crest width was 10 to 15 feet. Originally, all the tailings were deposited in one cell, in what is now referred to as the "east cell." The tailings dam was constructed from the coarser material and was built up by the centerline construction method.

Another cell, that is now referred to as the "west cell," was added in 1966. The method of construction was the same and this has resulted in one large pile. Since 1966, Homestake has alternated between the two cells to optimize the operating conditions. The east cell is the larger. The tailings produced under the AEC contract are in the bottom portions of both cells. Figure 3, which was furnished by Homestake, is an aerial view of the site that shows details of this large pile and other features on the site.

Originally, tailings disposal was done by spigotting the tailings slurry, which is 30 percent solids, off of the starter dam centerline and recovering the coarser material for building the outer embankment. After a few years, a method using wet cyclones was instituted. In this method, a cyclone positioned on the centerline of the embankment discharges the coarser tailings, which are used to build the dam at the outer embankment, and the fine tailings and liquid (slimes), which flow into the pond at the center of the bowl-shaped impoundment where the solids settle to the bottom. The decanted pond liquid is recycled back to the mill through the decant towers. Each of the cells contains a pond that has a depth of approximately 1 foot and an area of 25 acres. These ponds are used for evaporation of all liquid that is not recycled back to the mill for processing. The seepage from the toe of the pile is collected in ponds on the south side of the pile and recycled back to the mill.

In February 1977, there was an accidental release of tailings material from the east cell, which was caused by a failure in a tailings transportation line. This break resulted in release of some 100,000 tons of solid tailings that flowed to the south over 100 acres of land, all on the company property. The spill material was transported back onto the tailings pile, and the contaminated 2 to 3 feet of soil underlying the spill was scraped up and placed on the inactive Homestake-New Mexico Partners pile. No contamination of ground water by the liquids in the spill was observed because a clay layer under the spill prevented the tailings liquid from seeping into the alluvial aquifer.

Homestake's Radioactive Materials License requires close control of the tailings. Some of these conditions are:

- Maintain 5 feet of freeboard from top of dam crest to liquid level in pond.
- Survey embankment crest and pond levels monthly.
- Maintain 50 feet of beach from inside edge of crest to edge of pond.
- Keep tailings distribution line on inside edge of the embankment crest.
- Maintain an extensive lighting system around perimeter of pile.
- Ensure that two operators are present on the facility at all times during operations.
- Ensure that an alarm is installed in the flow line to sound if line failure occurs.
- Maintain roadways for easy access to the top of the pile.

To cope with the possibility of a breach, Homestake has constructed a retaining berm on its own property, one-quarter mile south (downgradient) of the tailings pile, to contain any possible spillage and prevent any off-site contamination.

As mentioned previously, the stability assessment for the tailings piles is made on the basis of calculations involving measurements of the phreatic levels in the embankment. Data are submitted to the New Mexico State Engineer monthly. D'Appolonia, a contractor, is preparing an assessment of the stability criteria for the tailings facility during the next several years of build-out.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The area is rural in character and, with two exceptions, there are no clusters of population in the immediate vicinity of the mill. These exceptions are the Broadview and Murray Acres subdivisions, which are located 1 mile south and west of the mill. The population there is about 200. The largest community is Grants, located 10 miles to the southeast, with a population of 10,500. The village of Milan (population 2600) is 7 miles to the southeast. The small community of Bluewater (population 300) is 7 miles to the west and the Anaconda housing area (population 250) is 5 miles to the west.

Due to the current depression in the uranium industry, the region is losing population as mines and mills are closed.

In order to minimize the possible effects of contamination of water, air, or land off the millsite, Homestake has purchased additional land adjacent to the site to provide a half-mile buffer zone around the original site. The cost of this land acquisition was $2 million.

WATER

The millsite is situated in the broad San Mateo drainage that drains the northwestern portion of Mt. Taylor and the southern part of San Mateo Mesa. The drainage basin has an area of some 290 square miles. Water flow in the drainage upgradient of the mill is ephemeral. The San-Mateo drainage trends generally to the south. The Homestake tailings piles and related facilities are protected from flooding by large retaining berms and diversion channels designed to withstand the "100-year flood."

The vegetation in the area is creosote brush, mesquite, sage, and pinon, and juniper at higher elevations.

The hydrology of the site is controlled by the underlying geologic conditions. The millsite is situated on the San Mateo Alluvium of Quaternary age. This Alluvium, which is 80 feet thick on the site, overlies the Chinle Formation (Triassic), which in turn overlies the San Andres Limestone (Permian). The upper part of the Chinle Formation underlying the site is shale with low permeability. This shale is the bottom of the aquifer in the Alluvium and it limits the downward seepage of shallow ground water. The natural flow of ground water in the Alluvium is about 100 gpm.

The ground water in the Alluvial aquifer is affected by seepage from the tailings. The seepage from the active tailings pile is approximately 100 gpm at the milling rate of 1500-1600 tons per day, and the pH of the tailings liquid is 10.

There are elevated concentrations of selenium, chloride, sulfate, and TDS in the areas near the tailings piles. The tailings liquid, when it is discharged into the ponds, contains the following approximate concentrations of sulfate, uranium, selenium, and molybdenum: 10,000; 50; 25; and 80 mg/l, respectively. Concentrations at much lower levels are found in wells in the alluvium at Broadview and Murray areas. High uranium levels are not currently present in the wells in the subdivision, but elevated levels exist near the tailings ponds. It does not appear that elevated concentrations of possible contaminants occur in the Chinle Formation.

Due to the possibility that the elevated levels of selenium in the wells at the two subdivisions could be related to seepage from the tailings piles, Homestake entered into a Ground Water Protection Plan Agreement with the EID in August 1976. The Agreement provided that Homestake would construct a system to contain seepage from the tailings into the ground water and provide a method to reduce selenium in the two subdivisions to background levels, regardless of the source or sources of the selenium. A certain part of the selenium content in the ground water may be naturally occurring, because some of the soils in the region contain abnormally high concentrations of selenium. A cooperative EID/Homestake ground-water monitoring program to verify the results is also part of the Agreement.

As a result, Homestake has installed a net of interceptor wells to prevent any future tailings seepage from going beyond this hydrologic draw-down boundary. Also, these wells are to draw back as much seepage as possible that may have escaped in the past.

Additionally, a line of recharge wells was drilled on Homestake property, downgradient of the interceptor wells. These are designed to inject fresh water, pumped from the San Andres Formation, into the Alluvial aquifers from which the wells in the two subdivisions obtain their water.

The operation of this plan is complex in detail, and continuous monitoring and checking of results by obtaining water samples for analysis is essential. All monitoring results are made available to the Environmental Improvement Division (EID) on a regular basis.

The EID required that Homestake submit a formal Ground Water Plan demonstrating compliance with the New Mexico Ground Water Protection Regulations. This report was submitted on December 1, 1981. According to Homestake, the plan was well received by EID, and the Agency has granted permission to continue operations.

The wells serving the municipal water systems in the Village of Milan and in the City of Grants have not been affected by tailings water seepage. Because of favorable locations with respect to regional ground-water flow patterns, it is believed unlikely that these wells will be affected by seepage from tailings ponds.

AIR

This area is in the climatological subdivision of New Mexico called the "southwest mountains." The dominant characteristics are low precipitation, sunny days, low humidity, and moderate average temperatures with large fluctuation in the diurnal and annual extremes. The mill is situated in a valley between easterly trending escarpments of Triassic sedimentary rocks to the north and the lava-capped Grants Ridge to the south. The winds, which are westerly, are channeled through this valley. Wind gusts commonly exceed 50 miles per hour. The relative humidity ranges from 65 percent at sunrise to 30 percent by afternoon, but commonly may be less than 15 percent. The mean daily temperature is 41°F, the mean maximum is 65°F, and the daily average is 54°F. Annual precipitation averages approximately 8.8 inches per year, but the maximum recorded was 13.5 inches in 1956. August is the wettest month with an average of 2.2 inches. Most of the precipitation falls as rain, but some snow falls during the winter. The area receives 75 percent sunshine in the winter and 80 percent in the summer.

Air monitoring for radioactivity is done regularly by Homestake in compliance with EID regulations. EID has eight continuous monitoring stations around the site and Homestake has five such stations. These stations measure the beta-gamma radiation of particulate materials collected. Homestake has always been in compliance with the air standards off-site, and no violations have ever been reported.

SURFACE CONTAMINATION

Windblown particles from the tailings piles have been deposited to the east of the piles. Determination of the extent and location of such windblown material would require radiation surveys. The problem has been alleviated by the periodic spraying of the active pile with a latex compound that cements the tailings particles on the sides and top of the pile. Most of the visible dusty material seen blowing on windy days is sodium carbonate that is used in the milling process, according to Homestake.

No tailings have been removed from the Homestake millsite for any purpose.

DISCUSSION OF VIABLE STABILIZATION PLANS

Parts of the New Mexico Radiation Protection Regulations discussed by Homestake that apply to tailings reclamation are:

(1) A deposit of $0.10 per pound of U_3O_8 produced must be deposited into the New Mexico Continued Care Fund until $1 million is on deposit. (Homestake had paid $740,000 into this fund by the end of November 1981.)
(2) Stabilization of Radioactive Milling Waste Radiation System.
  (a) Disposal of standing liquid after inactivation.
  (b) Stabilization as soon as practicable.
  (c) Protection of stabilized waste from runoff.
  (d) Restriction of public access and unauthorized use of tailings.
  (e) Regular inspection of stabilized systems.
  (f) Maintenance of records of surveys, inspections, and maintenance.
  (g) Development of plans and costs for stabilization and approval by EID.
  (h) Financial surety for stabilization, control, and maintenance.
  (i) EID approval prior to disposition of site.

Some of the more pertinent Nuclear Regulatory Commission (NRC) regulations cited by Homestake are:

(1) Require 5:1 stope after final stabilization.
(2) Require vegetation or rock cover.
(3) Require reduction of radon emanation to 2pC./m^2/sec.
(4) Minimum of 3 meters earth cover.
(5) Financial surety for reclamation.
(6) Long-term cost for surveillance; at time of decommissioning, $250,000.
(7) Require Government ownership of site.
(8) Require long-term site surveillance.
(9) Restrictions on contact between tailings and ground water.

One of the disturbing factors that confuses the issue of reclamation and stabilization, according to Homestake, is the uncertainty regarding what regulations will apply. Homestake pointed out that the NRC regulations are being challenged in the courts, and that the Stratton Amendment passed by the Congress in 1981 had stricken funds for enforcement of uranium milling regulations from the NRC appropriation bill.

The New Mexico Environmental Improvement Board, after extensive hearings and on the advice of the New Mexico Radiation Technical Advisory Council (RTAC), has adopted regulations which are, to the extent practicable in New Mexico, equivalent to or more stringent than NRC's requirements. The New Mexico regulations, which the Governor of the State has described as "soundly based in scientific, economic, technological, public health, and environmental considerations," differ in certain particulars from the regulations adopted by

NRC. Homestake estimated that the costs under NRC would be many times the costs under the EID. For total reclamation and stabilization under NRC regulations, the costs could be as high as \$100 to \$120 million based on an estimated cost of \$5 per ton. This would involve moving the tailings to another site for stabilization.

Under the Radiation Protection Regulations adopted by the New Mexico Environmental Improvement Board, Homestake will be submitting to NMEID an estimate of stabilization cost with its supplemental mill license renewal application in March or April 1982. This supplement will contain an engineered estimate of the stabilization cost under the New Mexico regulations. New Mexico has not yet adopted specific decommissioning regulations, and decommissioning and ground-water clean-up measures will not be included in this estimate.

DISCUSSION OF PROPOSED COST-SHARING PLANS

Homestake set forth the following items to be considered for Federal assistance:

(1) Stabilization of tailings pile.
(2) Surrounding land cleanup.
(3) Ground-water cleanup.
(4) Buffer zones to ensure the 25 millirem rule off Homestake property.
(5) Bonding cost and self-insurance to apply if NRC regulations prevail.
(6) Mill decommissioning.
(7) New Mexico Continued Care Fund.

The following Homestake comments are keyed to the numbered items above:

(1) The formula for cost-sharing on tailings should be based on the surface area of tailings pile. There is approximately 13 percent more area involved today than there was in pre-1971 because the pile has been built up, not out to cover more area. In the alternative, Homestake proposes that the formula for cost-sharing be based upon the percent the pounds of U_3O_8 in concentrate sold to the AEC bears to all pounds U_3O_8 in concentrate sold from the facility derived from ores milled in the mill.
(2) Aerial contamination should be on the basis of tons of material to be cleaned up. For windblown material, the time involved in blowing is also a factor, so costs could be based on tons and time (pre-1971 and post-1971).
(3) Ground water beyond the property boundary should be the Government's responsibility. The peripheral contamination is from the AEC tailings (these were the first tailings deposited). The ground water in the intermediate zone from the interceptor wells to the property lines and the areas inside the interceptor wells should be Homestake's responsibility.
(4) The \$2 million cost for the buffer zone should be based on a ratio of AEC pounds U_3O_8 to total pounds U_3O_8 either at the time of purchase or at the time of shutdown.
(5) Government to assume cost.
(6) Should be based on pounds U_3O_8 AEC versus total pounds U_3O_8.
(7) The Continued Care Fund should be on the basis of area of tailings.

Homestake also pointed out that the millsite must be signed over to the state or Government after stabilization. This will eliminate the possibility of Homestake making secondary recovery of uranium at some later date.

There was no agreement on principles for cost-sharing methodology or possible formulas.

REFERENCES

"Final Generic Environmental Impact Statement on Uranium Milling: Vols. 1, 2, and 3," U.S. Nuclear Regulatory Commission, September 1980.

"Ground-Water Discharge Plan for Homestake's Mill Near Milan, New Mexico," Hydro-Engineering, Casper, Wyoming, November 1981.

"Homestake Mining Company Commingled Tailings," Homestake Mining Company, a report to the Department of Energy.

"State of New Mexico Radiation Protection Regulations," Environmental Improvement Division, Radiation Protection Bureau, April 1980 and October 1981.

"Uranium Development in the San Juan Basin Region - Final Report," U.S. Department of the Interior, Fall 1980.

FIGURES

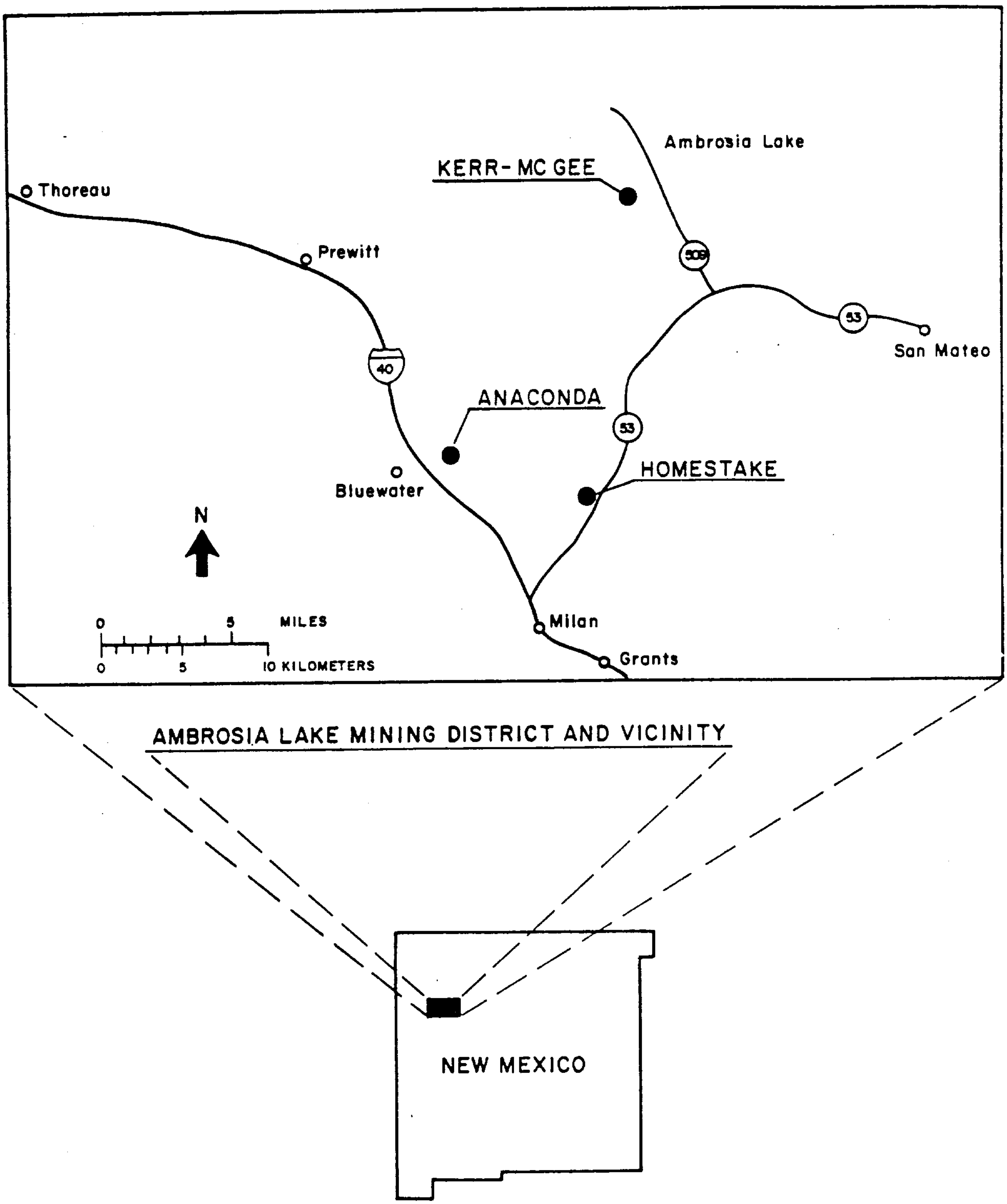

Figure 1. Location Map: Homestake Millsite, Grants, New Mexico

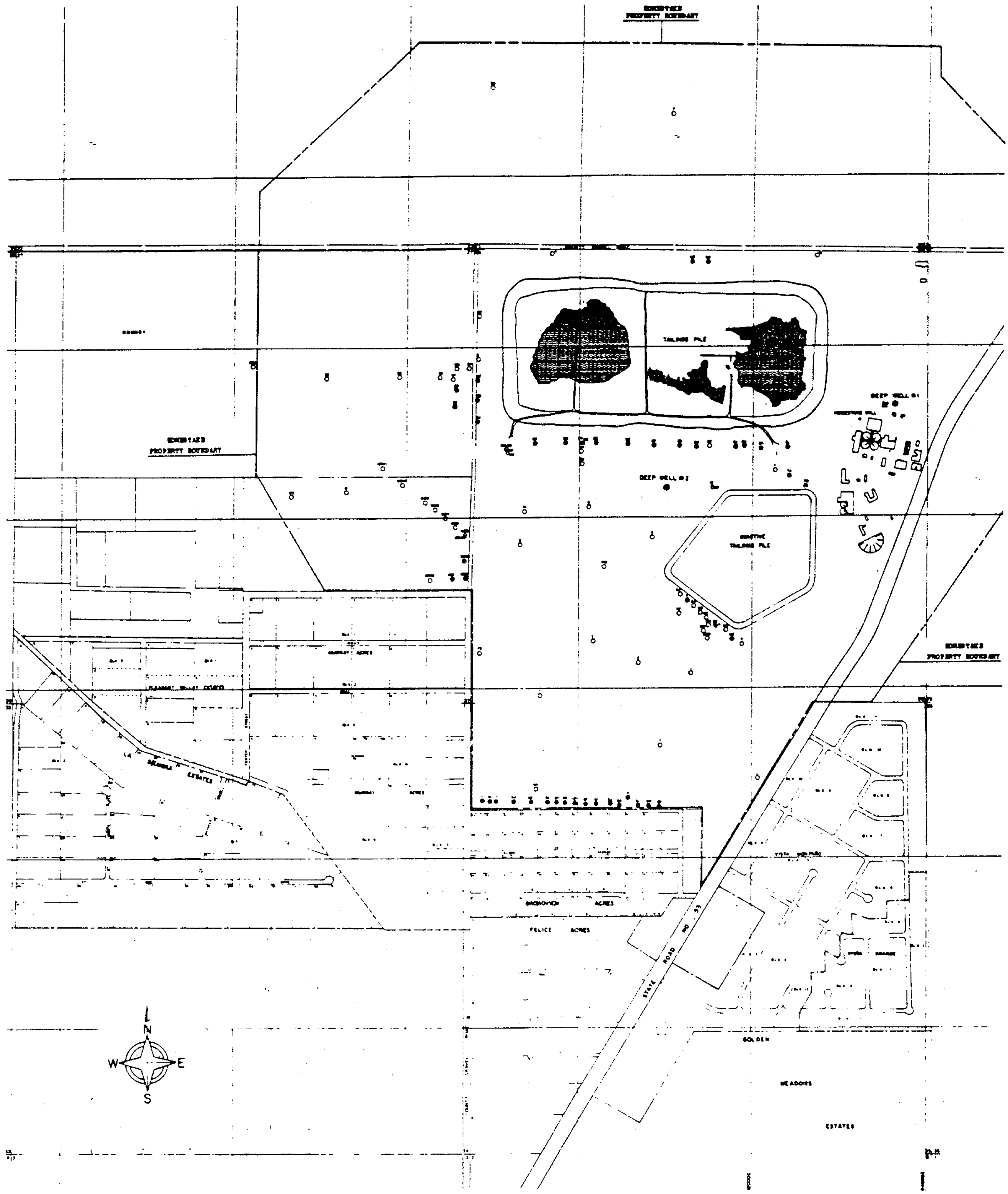

Figure 2. Plan View of the Homestake Millsite and Tailings Ponds

SITE REPORT: KERR-McGEE NUCLEAR CORPORATION
Grants, New Mexico

INTRODUCTION

The Kerr-McGee mill is located about 23 miles by road north of Grants, New Mexico (Figure 1). Grants is 78 miles west of Albuquerque on Highway 40.

Information in this report was obtained largely from discussions with Kerr-McGee (KM) representatives and from the Commingled Tailings Report furnished to the American Mining Congress (AMC) by Kerr-McGee. The Grand Junction Area Office (GJAO) files were utilized as needed for production data.

The KM Ambrosia Lake mill is currently operating under former AEC Source Material License Number SUA-616. The expiration date has been extended as provided by Section 3-430.B of the New Mexico Radiation Protection Regulations. KM is currently in the relicensing process with the State of New Mexico, which is an Agreement State.

BACKGROUND AND HISTORY

OWNERSHIP

The mill and tailings area is surrounded by fencing and is a controlled access area. All of the land surface within the restricted area is controlled either by direct ownership or through leases. Following is a listing by legal subdivision of the surface and mineral control of the properties within the restricted area:

Section: Township and Range	Surface: Ownership-Leasehold	Minerals: Ownership-Leasehold
31, 14N, 9W W/2 SW/4	Kerr-McGee	Kerr-McGee
32, 14N, 9W	Kerr-McGee	State, Homestake
NE/4 6, 13N, 9W	Indian Allotted, KM Business Lease	IA - Grace/Koppen Leasehold
NW/4 6, 13N, 9W	Kerr-McGee	Indian Allotted, Kerr-McGee
NE/4 1, 13N, 10W	Kerr-McGee (fee)	Santa Fe R.R. Pathfinder
SE/4 SE/4 36, 14N, 10W	State, Homestake KM Contract	State, Homestake United Nuclear
4, 13N, 9W	Kerr-McGee (fee)	Federal, KM

The mill is situated on Section 31, T. 14 N., R. 9 W.; the main tailings areas, Pond 1 and Pond 2, are mainly on Section 31, but also extend onto the north half of Section 6, T. 13 N., R. 9 W.; evaporation Ponds 3 through 6 are on Section 31; Ponds 7 and 8 are on Section 36, T. 14 N., R. 10 W. and Section 1, T. 13 N., R. 10 W.; Ponds 9 and 10 are on Section 32, T. 14 N., R. 9 W.; and Ponds 11-21 are on Section 4, T. 13 N., R. 9 W. (see Figure 2, which was furnished by KM).

Kerr-McGee Oil Industries, Inc., Anderson Development Corporation, and Pacific Uranium Mines Company formed Kermac Nuclear Fuels Corporation in the mid-1950s. The present company is Kerr-McGee Nuclear Corporation with headquarters in Oklahoma City, Oklahoma, and mine and mill offices at the Ambrosia Lake, New Mexico, millsite. On May 3, 1957, Kermac Nuclear Fuels Corporation and the U.S. Atomic Energy Commission signed Contract No. AT(05-1)-729. This purchase contract was for the delivery of U_3O_8 concentrate to the AEC. There were three modifications to the original contract. The first (November 28, 1960) changed the pricing formula, amended the AEC option to a firm commitment, and broadened the ore source for U_3O_8. The second (August 28, 1964) was the "stretch-out" contract, which reduced deliveries through 1966 and added 1967-through-1970 deliveries according to a detailed cost formula. The third (April 23, 1966) had no effect on quantity, prices, or schedules. The AEC contract was for purchase of U_3O_8 concentrate with no separate amount stated as a milling fee.

PRODUCTION HISTORY (FROM KERR-MCGEE)

A review of the amount of U_3O_8 in concentrate delivered to the AEC under Contract No. AT(05-1)-729 is as follows:

Period	U_3O_8 (pounds)	Price ($/lb.)
1958-10/31/60	8,767,275	7.033
11/01/60-05/10/63	13,782,725	6.723
05/11/63-12/31/68	17,729,486	8.00
01/01/69-12/31/69	3,022,727	5.671
Total	43,302,213[a]	7.235 (average)

[a]Checks with DOE records. The total pounds U_3O_8 produced to 12/31/69 were 50,092,278.

The original licensed capacity of the mill was 3630 tons per day in 1958, but later, during the AEC contract period, it was increased to 5000 tons per day.

The mill was constructed to treat ores from the undergound mines in the Ambrosia Lake Area, which was discovered by drilling in 1955. All KM mines are in sandstones of the Morrison Formation (Jurassic). KM has produced ore from 10 mines at Ambrosia Lake. Two mines, Sections 22 and 10, have been closed for conventional mining, and three mines, Sections 17, 24, and 33, are on standby due to the present depressed uranium market.

The mill started up in 1958 and has been in continuous operation since that time. Concentrate was produced for sale to AEC from 1958 to December 31, 1969. During this period, the mill processed 11,948,899 tons of ore. Of this total, 188,684 tons were processed for others, and ore also was processed for sale on the commercial market. KM has continued to be a major U_3O_8 producer for the commercial market with a total of over 29 million tons of ore processed through 1980.

In addition to the mines at Ambrosia Lake, KM also processes ore from its mines at Churchrock, New Mexico, which are approximately 45 miles to the west of Ambrosia Lake. Uranium is also recovered from mine water. In the past, uranium was also recovered from roasted lignite residues shipped to the mill from mining operations in North Dakota. The mines furnished ore for the KM mill in January 1982 as follows:

1. Kerr-McGee - Captive (75% of total)
   a. Ambrosia Lake
      Sections 19, 30, 30 W., 35, 36 (75%)
   b. Churchrock
      Churchrock #1 and #1 East Mines (25%)

2. Toll Ore for Other Companies (25% of total)
   a. Gulf Minerals
      Mariano Lake and Mt. Taylor Mines
   b. Western Nuclear
      Ruby 3 and Ruby 4 Mines
   c. Cobb Nuclear
      SW[4] Section 12 and Section 14 Mines

d. Spider Rock Mining
   Section 27 (a UNC section)
e. Ranchers Exploration & Development
   Johnny M Mine

The overall grade of ore presently being milled ranges between 0.17 and 0.18 percent U_3O_8. The grades of toll ore are slightly higher than grades of captive ore.

PROCESS DESCRIPTION AND MAJOR CHANGES

The Mill

KM started milling operations at its Ambrosia Lake facility in November 1958 at a rated capacity of 3630 tons per day. The rated capacity today is 7000 tons per day, but, at present, ore fed to process is slightly less than 6000 tons per day.

Briefly, the ore is leached with sulfuric acid (pH ranges from 0.6 to 1.2 in the leaching circuit). Then the pregnant solution is separated from the sand and slime solids in a countercurrent decantation circuit, utilizing cyclones, classifiers, and thickeners. Sodium chlorate and steam are added at several places in the circuit to maintain oxidation potential and temperature. The pregnant solution is clarified and sent to the solvent extraction circuits where an organic phase is used to collect uranium and molybdenum. The loaded organic is then fed to a stripping circuit where a brine (sodium chloride) solution separates the uranium from the organic phase. Uranium is precipitated from the highly enriched brine solution through the use of ammonia. Molybdenum is treated in a separate stripping circuit where it is scrubbed with ammonia solution. Molybdenum in the ores is a contaminating element, and separation is necessary to maintain the desired purity of the uranium concentrate. The final uranium product grades 86 to 90 percent U_3O_8. The overall extraction of U_3O_8 from the ore exceeds 96 percent. There have been no important process changes, according to KM; only fine-tuning of the basic process has been required.

Currently, the mill produces approximately 6000 tons of solid tails and 8700 tons (about 2 million gallons) of liquid tails per day. Disposal of liquids is by evaporation from evaporation ponds. The solid tailings are impounded in Ponds 1 and 2. The liquid in Pond 1 has a pH of 1.5. KM has plans to do more recycling of liquid tailings to reduce the amount of tailings liquid to be evaporated.

A 400-ton-per-day sulfuric acid plant, which was constructed in conjunction with the mill facilities, supplies the process-acid requirements.

Heap Leaching, Mine Water Treatment

Heap leaching of ore was attempted at the Section 17, 24, 30, and 33 mines, but it was unsuccessful. These leach piles were cleaned up and the material was fed to the mill. On the site of Pond 4, an acid heap leach was conducted on ore from Sections 22 and 33, but this was also unsuccessful due to formation of gypsum. About 200,000 tons were involved, and some of the material is still at the Pond 4 site.

In addition to the milling process for uranium recovery, KM also operates ion-exchange (IX) facilities for the recovery of uranium from mine water. One IX plant is located at the millsite and removes uranium from all of the KM mine waters at Ambrosia Lake with the exceptions of Sections 35 and 36 mines. The millsite IX unit treats about 2500 gpm. The second IX unit at Section 35 mine treats about 1500 gpm, and the loaded resin from Section 35 is trucked to the IX unit at the mill. The third IX unit, planned for the KM mining operations at Churchrock, is licensed for 4000 gpm. The uranium solutions from Churchrock will be trucked to the KM mill for treatment. Subsequent to ion exchange for uranium recovery, the waters are treated with barium chloride which precipitates barium sulfate that picks up radium sulfate as a co-precipitate.

The mine waters contain from 2 to 12 ppm U_3O_8, and uranium extraction from mine waters exceeds 85 percent. Nearly 1 percent of the mill production is attributed to mine waters.

SITE DETAIL

LOCATION

The KM mill, tailings, and associated evaporation ponds are located in the Ambrosia Lake area, about 17 air miles north of Grants, New Mexico (Figure 1). The mill and tailings and Ponds 3 through 10 occupy mainly Section 31, T. 14 N., R. 9 W., and Ponds 11 through 21 occupy most of Section 4, T. 13 N., R. 9 W. The area is reached by traveling north from Milan, New Mexico, on State Highways 53 and 509.

TOPOGRAPHY

The mill is situated at about 7000 feet elevation in a northwesterly trending valley, which is defined on the north by sandstone cliffs and shale sloes of the Mesaverde Formation and on the south by a rim outcrop of Dakota Sandstone. The undulating valley is underlain by the Mancos Shale. The mill itself is on the western slope of a small local drainage feature, called Arroyo del Puerto, which drains southeasterly from the mill.

CURRENT CONDITION OF TAILINGS

Figure 2 (furnished by KM) shows the location of tailings Ponds 1 and 2, where all of the solid tailings from the mill are stored. In addition, this map shows the location of the mill and evaporation Ponds 3 and 5 through 10. Pond 4 is located just north of Pond 5 and is off the map. The map area covers part of Section 31, T. 14 N., R. 9 W.

Pond 1 extends southeasterly from the mill area for about 4500 feet, and its greatest width in an east-west direction is about 2700 feet. The elevation of the outside berm averages about 7020 feet and ranges from 25 to 90 feet above the original ground. Currently, only a small amount of tailings is being stored in Pond 2 and its main function now is evaporation. Pond 1 is the active area for deposition of the tailings slurry (see Figure 3, which was furnished by KM).

The tailings slurry from the mill, which is about 40 percent solids, is pumped through spigots which discharge inside the berm around the top of the tailings pile. There are a number of roads providing access to the berm and the face of the tailings pile.

KM refers to the condition of the tailings at present to be "stable, well contained, and well managed." The pile is inspected daily to confirm the structural stability and to monitor for spills, abnormal erosion, or sloughing. The State Engineer also inspects the tailings pile regularly, and KM furnishes reports to the State Engineer periodically.

QUANTITIES OF TAILINGS

KM does not have an aerial photo map or cross sections that show the aereal extent or the three-dimensional configuration of the Ponds 1 and 2 tailings piles as of December 31, 1969, the termination of AEC purchases. KM does have an aerial photo of the site, which was taken November 10, 1967. According to KM, this photo is representative of the conditions existing in 1970, because most of the tailings deposited from 1969 through 1970 mainly added height to the piles, with only a small increase in areas. According to KM, in 1981, Pond 1 covers approximately 263 acres and contains a liquid area of approximately 90 acres. Pond 2, which covers approximately 65 acres, is west of and contiguous with Pond 1. This is a total area of 328 acres for these two tailings ponds. Examination of the 1967 aerial photo (Figure 4, furnished by KM) shows that the area of involvement for Pond 1 at that time may have been roughly 40 acres less than is shown on more recent aerial photography (Figure 5, furnished by KM). This increase in area of tailings involvement since 1967 appears to be mostly in the southwest portion of tailings Pond 1. The total area of tailings involvement, including Ponds 1 and 2 and evaporation Ponds 3 through 8, for 1967 is estimated at 539 acres by KM. KM estimates that the ultimate area of tailings involvement in 1998 (termination of operations) will be 700 acres.

The quantities of ore processed (in tons) and their distribution, as provided by KM, are as follows:

	1958-1969[a]	1970-1980	Total
Government	10,031,748	0	10,031,748
Commercial	1,318,951	17,153,331	18,472,282
Backfill	598,200	601,800	1,200,000
Totals	11,948,899	17,755,131	29,704,030

[a]KM produced U_3O_8 for sale to the AEC up to 12/31/69.

The quantities designated "backfill" represent the tonnages of classified sand tailings taken from the pond and used as mine backfill. Backfilling was used in the mines to prevent surface subsidence and intermixing of aquifers, to improve safety, and to permit more complete ore recovery.

It is assumed that the U_3O_8 derived from toll-milled ore was sold to the AEC in the same ratio as U_3O_8 derived from KM ore. To determine the ratio for toll-milled U_3O_8, the AEC-purchased U_3O_8 must be divided by the total U_3O_8 produced from company-owned ore (total production minus toll-milled production).

(a)	KM Total U_3O_8 Production Through 1969	= 50,092,278 lbs. U_3O_8
(b)	U_3O_8 Production from Toll Milling	= 1,094,870 lbs. U_3O_8
(c)	Net U_3O_8 Produced from KM Ore	= 48,997,408 lbs. U_3O_8
(d)	AEC-Purchased U_3O_8 from KM Ore	= 43,302,213 lbs. U_3O_8

The ratio for toll-milled sales:

$$\frac{d}{c} = 0.8838$$

The tailings attributable to AEC contracts is calculated as follows:

Total Ore Fed = Total Tailings	=	11,948,899 tons
	x	0.8838
AEC-Related Tailings	=	10,560,437 tons
Commercial Tailings	=	1,388,462 tons

Then if the amount of tailings removed for backfill is calculated with the same ratio:

598,200 x 0.8838 = 528,689 tons (AEC share)
69,511 tons (commercial share)

The final quantities remaining in the tailings pile at the end of the AEC contract were:

AEC-Related:	10,560,437 - 528,689	= 10,031,748 tons
Commercial:	1,388,462 - 69,511	= 1,318,951 tons
Total Tailings in the Pile at 1/1/70		= 11,350,699 tons

The following table summarizes these tailings data for KM operations through 1980. All figures are tons of solid tailings.

	7/1/58-12/31/69	1/1/70-12/31/80	7/1/58-12/31/80
AEC-Related	10,031,748	0	10,031,748
Commercial	1,318,951	17,153,331	18,472,282
Totals	11,350,699	17,153,331	28,504,030[a]

[a]Total tailings through 12/31/81 are 30,413,331 tons.

The DOE data on tons of ore fed to process through 1969 and 1980 are essentially in agreement with the KM data.

On the basis of its current reserves, KM estimates that the mill could operate until 1998. This plan would process ore at the rate of 6200 tons per day for 342 days per year, and would produce an additional 38,167,200 tons of tailings for a total of 67,871,230 tons (KM number) produced by year 1998. The area of such a pile, including Ponds 1 through 8, would be about 700 acres, according to KM.

The following table summarizes the amount of tailings and area of Ponds at the end of the AEC contract, at the end of calendar year 1980, and at the date of shutdown.

	Amount of Tailings and Areas of Ponds		
	1/1/70	1/1/81	1/1/99[a]
Tailings (tons)[b]			
AEC-Related	10,031,748	10,031,748	10,031,748
Total	11,350,699	28,504,030	66,671,230
Percent AEC Is of Total	88	35	15
Area (acres)			
Ponds 1 and 2	N.A.	328	-
Ponds 1 through 8	539	N.A.	700
Pile Height (feet)[c]	25-65	25-90	25-160

[a]KM-estimated data for shutdown.

[b]All tonnages adjusted for mine backfill.

[c]Approximate.

TAILINGS MANAGEMENT HISTORY

The tailings disposal area was constructed in 1958 and consisted of six ponds. Ponds 1 and 2 were used for solid tailings disposal. Pond 3 was a decant and seepage collection pond, and Ponds 4, 5, and 6 were used for evaporation. All starter dikes and berms were constructed of natural soils on the site. As the mill capacity increased, additional ponds were added for evaporation. Ponds 7 and 8 were built in early 1960, 9 and 10 in 1976, and 11 through 15 in 1976. Ponds 16 through 21 were put into use in 1979 and 1980. Ponds 9 through 21 are lined ponds.

The tailings management plan in use today is essentially the same as that in use when the mill commenced operations in 1958. The tailings dam is built up by the upstream method of tailings disposal. The basic plan is to retain and stabilize all solid tails and dispose of liquid tails through evaporation. Currently, the mill is producing about 6000 tons of solid tails and 8700 tons of liquid tails per day. The slime tails and the sand tails are repulped with liquid, which produces a slurry with 40 percent solids for transport via pipeline to Pond 1. The slurry goes to a distributor box at the mill end of Pond 1 from which it is directed by electrically controlled valves to either side of the Pond through pipelines. These pipelines are fitted with spigots at 30-foot spacings. The slurry is discharged inside a berm formed from the coarser tailings. The bulk of the coarser tailings are deposited on a beach inside the berm, and the slime fraction and liquid tails flow into the central depression forming a lake. After drying, the sands inside the berm are bulldozed into a new and higher berm. In the impoundment, the slimes settle, and the clear decant liquid that is not recycled for reuse in the mill is piped to the evaporation ponds. In addition to Pond 1, the main tailings pond, there are 20 other ponds for evaporation of liquids. Evaporation in the Ambrosia Lake area is between 4 and 5 feet per year.

There have been no problems with tailings pile stability. Stability is maintained in compliance with orders from the State Engineer to maintain minimum length of tailings beach in relation to elevation of the tailings pile. The phreatic surface (level of ground moisture) is monitored by 31 piezometers.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The area is still predominantly rural in character. There are no clusters of population within the immediate vicinity of the mill. The closest communities are San Mateo and Lee Ranch and Prewitt, which are approximately 12 air miles southeast and west of the site, respectively (Figure 1). The population in the San Mateo area is about 250 and Prewitt about 160. The village of Bluewater and the Anaconda community housing are about 14 and 13 air miles, respectively, to the southwest. The population of Bluewater is about 300 and the Anaconda site (which will be closed down subsequent to March 31, 1982) is about 250. The village of Milan, which has a population of 2600, is about 16 air miles to the south, and the largest town, Grants, which has a population of 10,500, is about 17 air miles to the south. Due to the current poor uranium market situation, the entire region is losing population as the mines and mills are shut down.

WATER

The hydrology of the site is controlled by the underlying geologic conditions. The mill is situated on the Mancos Shale and intercalated beds of sandstone called the Tres Hermanos. These sandstone beds contained some minor amounts of water prior to mining operations. Other formations in the area are the Dakota and Brushy Basin and Westwater Members of the Morrison Formation. Both the Dakota and Westwater are aquifers, but the natural water in the Dakota is lower in quality than water in the Westwater. In the Ambrosia Lake area, the Westwater has been locally drained to permit mining to take place. The surface hydrology is controlled by arroyos and alluvium that are as much as

100 feet thick at Ambrosia Lake. Prior to mining and milling operations, this alluvium was dry.

The mine dewatering and milling operations have created changes in the hydrologic conditions in the area. Mine dewatering has created a depressed ground-water level in the sandstone aquifers at and above the level of the mines downgradient from the mill. KM monitors the ground-water conditions through wells; some 70 wells had been completed by 1980 and about 57 are being monitored at present. Some of these wells are dry or nearly dry. A portion of the water from the unlined mill ponds, numbers 1 through 8, seeps into the underlying formations and the alluvial material in the Arroyo del Puerto, which is east of the millsite. About one-third of the liquid in the unlined ponds seeps into the subsurface and about two-thirds evaporates. Seepage from these ponds enters the sandstone aquifers of the Tres Hermanos and the Dakota Formation as well as the alluvium. The alluvial deposit is now virtually full due to infiltration of mine drainage water and the seepage from unlined evaporation ponds. This fluid in the alluvium ranges from 1000 mg/l total dissolved solids near the boundaries of the alluvium to over 9000 mg/l near the ponds.

KM says that these conditions are not problems at this time from a practical point of view, because the water is not being used now, and there is no evidence that it will be used in the future. There are no wells that tap this water for domestic or agricultural use. It was mentioned that the low pH (1.5) of the mill liquids seeping from the ponds into the subsurface is buffered by the higher pH of the natural soils and waters. Also, this action usually takes place within a few hundred feet of the unlined ponds, resulting in an ultimate pH of 7 to 8, which is normal for the area. This buffering action also results in the precipitation of the heavy elements, including the radionuclides. KM has proposed to the New Mexico Environmental Improvement Division (EID) several measures to minimize seepage which include abandonment of Ponds 4, 5, 6, 7, and 8, installation of an interceptor slurry trench, and an increase in recycle of tailings liquid.

AIR

The area is in the climatological subdivision of New Mexico called the "southwestern mountains." It is characterized by low precipitation, sunny days, low humidity, and moderate average temperatures with large daily and annual extremes. The mill is situated in a broad northwesterly trending valley at an elevation of 7000 feet. The predominant wind directions are westerly and northwesterly and are channeled by the valley. Wind gusts can exceed 50 miles per hour. The relative humidity ranges from 65 percent at sunrise to 30 percent by afternoon, but often drops to less than 15 percent. The mean daily temperature minimum is 41°F, the mean maximum is 65°F, and the mean daily average is 54°F. Precipitation averages about 8.8 inches per year. The maximum recorded was 13.5 inches in 1956. August is the wettest month with an average of 2.1 inches. Most of the precipitation falls as rain, but snow falls in the winter months. The area receives 75 percent of possible sunshine in the winter and 80 percent in the summer. Radon does not seem to be a problem off-site. EID reports it is difficult to determine the amount of radon attributable to tailings versus the amount coming from the many mine vent shafts.

SURFACE CONTAMINATION

KM said that windblown tailings have not been a serious problem. The sand portion of the tailings, even in high winds, ordinarily drops within one-half mile of the tailings pile. It was pointed out by KM that the surface of the tailings pile, where undisturbed, tends to crust over as the result of cementing action of secondary gypsum that forms in the upper 1 to 2 inches of the pile. The EID has several air monitoring stations around the area of the pile. KM is unaware that the results of the monitoring indicate any health problems. The prevailing wind direction, according to KM consultant analysis of EID meteorologic data, is slightly north of west. The Lee Ranch is the nearest resident for this direction, and a dose assessment run by KM consultants using EID meteorologic data indicates that the 25-millirem rule for the nearest population cluster can be satisfied. Monitoring data are collected and analyzed regularly.

DISCUSSION OF VIABLE STABILIZATION PLANS

This item was discussed with the KM representatives at the November 1981 meeting at the KM millsite, and is additionally addressed in the KM report to the AMC and in a letter to the GJAO Manager, dated January 28, 1982.

The following discussion was furnished in its entirety by KM. It was an enclosure in a KM letter dated February 23, 1982, addressed to the Manager, GJAO. This discussion summarizes the points in the AMC report and January 28 letter, and is an up-to-date statement of the KM viewpoint on reclamation, stabilization, and decommissioning operations at the millsite.

> Due to uncertainties concerning what regulations might apply by 1998, the projected time of shutdown, there may well be changes in the KM plans for stabilization in the future. KM pointed out that EPA has not yet issued standards for active sites and NRC regulations are being challenged in the courts.
>
> The major reclamation and stabilization tasks presented by KM are as follows:
>
> <u>Tailings Reclamation</u>. This will involve stabilization of the tailings pile. Requirements applicable to stabilization will depend on regulations finally adopted by the State of New Mexico and to the extent provided under the Uranium Mill Tailings Radiation Control Act, the NRC and EPA. The current NRC regulations require a minimum 3 meters of earthen cover, additional cover as required to limit radon flux to 2 pCi/m^2-sec, slopes no greater than 5:1, rock or vegetative cover, and below-grade disposal or equivalent.
>
> <u>Mill Site Decommissioning</u>. This task will involve dismantling all process equipment and buildings and regrading the land after removal of radioactive contamination. Nonsalvageable equipment will be buried in the tailings pile. No EPA standards or NRC requirements have been promulgated for decommissioning at this time.

Reclamation of Evaporation Ponds. This will involve drying out of the ponds and removal of contaminated sediments to the main tailings disposal area, Ponds 1 and 2. Regrading the ponds and fertilization and seeding of the areas will be carried out.

The New Mexico Environmental Improvement Board, after extensive hearings and on the advice of the New Mexico Radiation Technical Advisory Council (RTAC), has adopted regulations which are, to the extent practicable in New Mexico, equivalent to or more stringent than NRC's requirements. The New Mexico regulations, which the Governor of the State has described as "soundly based in scientific, economic, technological, public health and environmental considerations," differ in certain particulars from the regulations adopted by NRC.

KM has provided estimates of direct costs to comply with both the NRC regulations and the current New Mexico regulations as follows:

Cost Area	Estimates to Comply with NRC	Estimates to Comply with New Mexico
Tailings Reclamation	$11,382,860	$4,672,000
Evaporation Ponds Reclamation	6,014,000	6,014,000
Millsite Decommissioning	1,785,400	1,785,400
Totals	$19,182,260	$12,471,400

KM indicates that, under the most favorable assumptions, the labor and material expenses for reclamation and decommissioning in 1998 under NRC regulations will be $19 million minimum in 1981 dollars. The assumptions made by KM for the NRC cost are:

1. Burial of nonsalvageable material and contaminated sediments from ponds is permitted.
2. Only 3 meters of earth and rock cover over the tailings is required. Also, that cover is 2 feet of compacted clay, 7 feet of earth fill, and 1 foot of soil.
3. That final configuration utilizing 5:1 slope is permitted.
4. That local Mancos Shale can be reworked to provide suitable sealant.
5. That sufficient borrow material is available within limits of site.
6. That rock riprap can be quarried from sandstone within 6 miles of site.
7. That the tailings pile will dry out so heavy equipment can be used.
8. That grading equipment will not be unduly corroded.
9. That no requirements be imposed on account of seepage from the tailings pile.
10. That interim stabilization of tailings is not required.

KM estimates that the NRC estimated cost could easily be in excess of $100 million if regulatory authorities impose more stringent license requirements under current regulations or if unforeseen technical problems arise. In this regard, KM cites the possibility that below-grade disposal of material might be required, and, if so, the material would have to be relocated. Also, relocation for above-grade disposal at another site might be required. In such cases, KM says cost could increase by an order of magnitude, a factor of 10.

KM indicates that under the more practicable regulations adopted by the State of New Mexico, labor and material expenses will be around $12.5 million in 1981 dollars. Assumptions made by KM for the New Mexico estimate are:

1. All equipment that cannot be decontaminated will be buried in tailings pile.
2. All building materials except metal building frames will be dumped in tailings pile.
3. No more than 1.7 feet of sediment will need to be removed from water storage ponds.
4. Revegetation will be no more than density of contiguous lands.
5. Average of 2 feet of soil removed from mill process area.
6. Average of 4 inches of soil removed from immediately adjacent mill area.
7. Side slopes of main tailings pile to be no less steep than 2.5h to 1v.
8. The tailings cover will resist erosion for 200 years.
9. Surface hydrology provides for the 100-year storm.
10. Shale from KM-owned Section 22 will be used for dirt cover.
11. Top of the pile slopes 1.5 percent toward the center to provide a depositional condition.
12. Unlined ponds will require an average of 3 feet of soil removed.
13. Lined ponds will require removal of 1 foot of soil beneath the liner.
14. Suitable rocks for cover can be obtained within 9 miles of the site.

Costs identified by KM which are not included in either of the above estimates are as follows:

1. Storm-water runoff diversion.
2. Ground-water or surface-water cleanup.
3. Cleanup of surrounding lands.
4. Land acquisition for buffer.
5. Long-term monitoring and maintenance.
6. Interim stabilization.
7. Judicial awards.
8. Indirect costs such as health physics, environmental control, engineering, supervision, administrative overhead, contractors' fees, and contingencies.
9. Future costs resulting from regulatory changes.

DISCUSSION OF PROPOSED COST-SHARING PLANS

During the November 1981 meeting with KM representatives at the mill in Ambrosia Lake, the suggestion was made by KM that a better basis for cost distribution than AEC tons versus total tons processed would be a ratio of the area of tailings produced under the AEC contract to the total area of tailings at time of reclamation.

This approach is discussed further in a letter from KM to the Manager, GJAO, dated January 26, 1982. In essence, KM suggests that millsite decommissioning costs should be based on total pounds of concentrate produced, but that stabilization of tailings and related decontamination costs are directly related to areas of land involved. KM suggests the following formula for cost sharing:

$$\frac{A_1}{A_2} \times C_1 + \frac{B_1}{B_2} \times C_2 = T$$

A_1 = Area to be reclaimed at end of 1969 assumed to be the same as at the end of 1967.
A_2 = Total area to be reclaimed at end of mill life.
B_1 = Pounds U_3O_8 purchased by AEC.
B_2 = Total pounds U_3O_8 produced by mill to end of mill life.
C_1 = Cost of tailings retention system stabilization.
C_2 = Cost of mill decommissioning.
T = Total DOE share of cost.

Kerr-McGee believes a cost-sharing plan based on a ratio of areas of tailings involvement and contamination of land would be more equitable than a ratio based on tons processed for the AEC contract versus total tons in the pile. This is because most of the tailings impounded following the AEC contract period were placed on top of the impoundment areas already utilized for storage during the AEC contract period. The piles were mostly built up in height rather than laterally to include more area.

No agreement has been reached on either a philosophy or formula for a cost-sharing plan.

REFERENCES

"Final Generic Environmental Impact Statement, Vols. 1, 2, and 3," U.S. Nuclear Regulatory Commission, September 1980.

"Report on Ambrosia Lake Mill Commingled Tailings," Kerr-McGee Nuclear Corporation, May 1981.

"State of New Mexico, Radiation Protection Regulations," Environmental Improvement Division, Radiation Protection Bureau, April 1980 and October 1981.

"Uranium Development in the San Juan Basin Region - Final Report," U.S. Department of Interior, Fall 1980.

FIGURES:

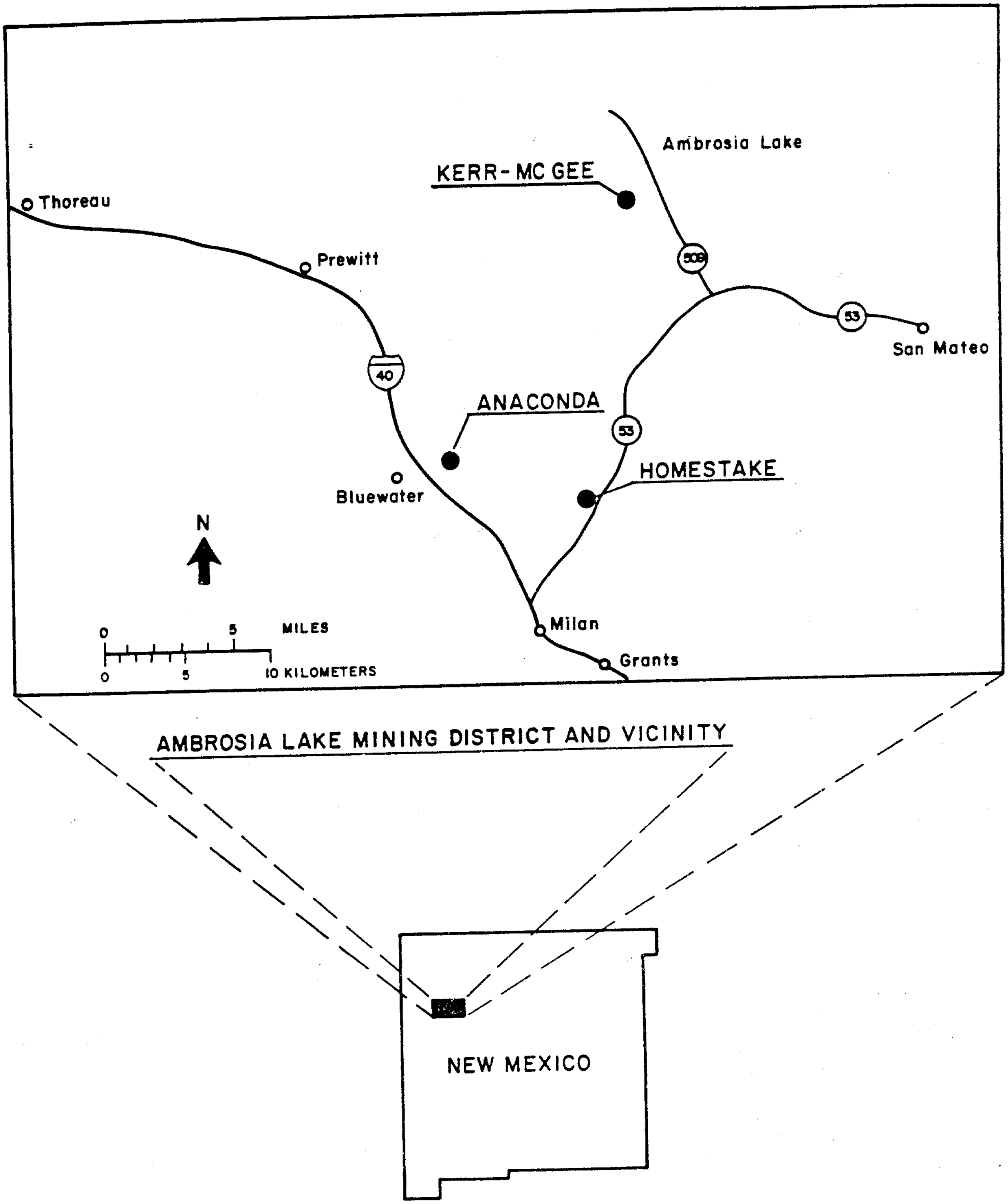

Figure 1. Location Map: Kerr-McGee Millsite, Grants, New Mexico

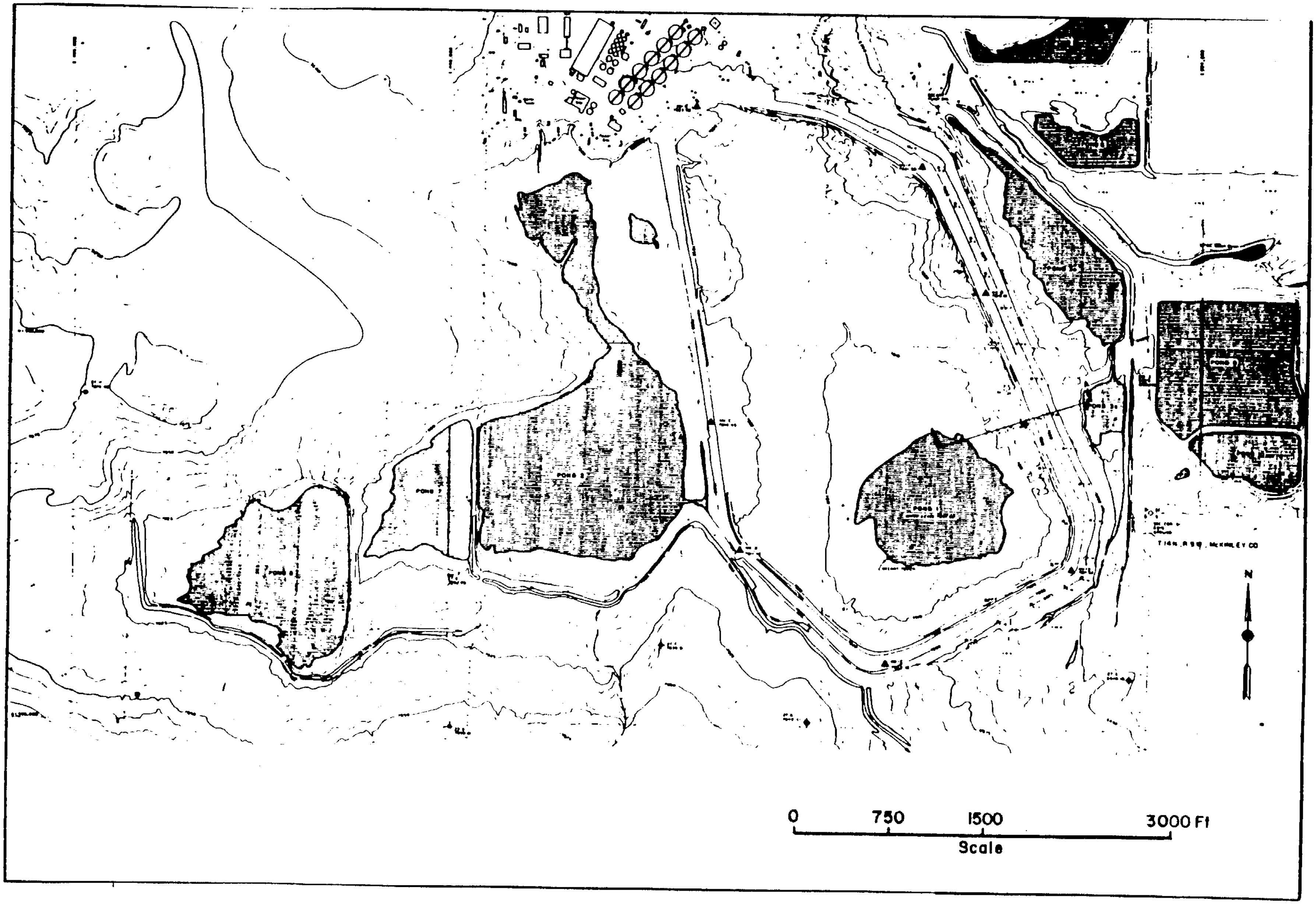

Figure 2. Plan View of the Kerr-McGee Millsite and Tailings Ponds

SITE REPORT: TENNESSEE VALLEY AUTHORITY
Edgemont, South Dakota

INTRODUCTION

Included among the thirteen commingled tailings sites is the Edgemont, South Dakota, site, even though the mill has not operated since August 1974 when the Tennessee Valley Authority (TVA) purchased the mill and certain mineral rights from Susquehanna Western, Inc. The Edgemont uranium mill is a U.S. Nuclear Regulatory Commission (NRC) licensed facility, and the license may not be terminated until the licensee (TVA) has complied with NRC requirements regarding decontamination, decommissioning, and reclamation of the sites, structures, and equipment used in mill operations. Accordingly, TVA prepared the "Edgemont Uranium Mill Decommissioning Plan Environmental Report," February 26, 1979. The NRC issued a Federal Register notice requesting comments by interested parties on the project and held a public scoping meeting in Edgemont on October 25, 1979. The NRC staff then prepared and issued a "Draft Environmental Statement Relating to the Decommissioning of the Edgemont Uranium Mill," September 1981.

By letter of August 11, 1981, TVA provided DOE-Washington with a summary report on the Edgemont site for DOE use in the commingled tailings study. Although TVA is a Federal agency, the Edgemont project is under the TVA power production organization which is funded by rate payers and does not receive Federal appropriations. TVA wishes to be considered as a "quasi corporation" and treated as any other commingled site owner. This report summarizes data and information available at GJAO as well as that provided by TVA, its management services contractor, Silver King Mines, Inc., and the above-cited references.

BACKGROUND AND HISTORY

OWNERSHIP

The Edgemont, South Dakota, uranium-vanadium ore processing mill and tailings are on land owned by TVA since August 16, 1974. TVA purchased the property from Susquehanna Western, Inc. (SWI), a totally owned subsidiary of Susquehanna Corporation, Chicago. The original site was acquired early in 1955 by Mines Development, Inc. (MDI), which became a wholly owned subsidiary of the Susquehanna Corporation in 1958.

The mill was constructed on property adjacent to about 6.5 acres of land leased by the AEC in 1952 from the Chicago, Burlington, and Quincy Railroad Company for an ore-buying station. MDI took over the operation of the ore-buying station on July 2, 1956, upon assumption of the land lease and acquiring the buildings and equipment from the AEC at the net book value ($60,255).

The initial source materials license was issued by the AEC in 1956. The TVA is the present licensee for the site.

PRODUCTION HISTORY

Ore was purchased and stockpiled by the AEC at Edgemont from December 1952 until June 12, 1956, and amounted to 105,250 tons containing 0.24 percent U_3O_8 and 0.30 percent V_2O_5. All this ore was sold to MDI at AEC inbound costs.

The initial AEC contract to purchase U_3O_8 at a negotiated price was signed with MDI on April 28, 1955. MDI proposed building a new mill at either New Castle, Wyoming, or Edgemont, South Dakota. MDI selected the latter site, constructed the mill, and started operation on July 3, 1956. The mill was regarded as a custom mill since MDI had little or no captive ores. It had a capacity of about 250 tons of ore per day, but within a year was expanded to 400 to 500 tons of ore per day. Capital investment in the mill and related facilities, including initial tailings disposal areas, was $2,157,735 ($1.25/lb. U_3O_8 for amortization purposes was included in the price AEC paid MDI).

Uranium was recovered during the period 1956 through 1972 from ore that averaged 0.18 percent U_3O_8. Uranium recovery at Edgemont was excellent, averaging about 95 percent. From 1956 through 1968, the AEC purchased 6,072,501 pounds of U_3O_8 at an average price of $8.91 per pound, under Contracts AT(05-1)-291, -907, and -929, as shown in Table 1. From 1958 through 1972, an additional 774,200 pounds of U_3O_8 were sold by MDI in the commercial market.

Table 1. AEC Purchases of U_3O_8 from Edgemont Mill

Contract No.	Period (FY)	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-291	1957-1962	2,685,232	10.01
AT(05-1)-907	1962-1968	3,322,462	8.03
AT(05-1)-929	1967-1969	64,807	8.00
Totals	1957-1969	6,072,501	8.91

Since the vanadium content of Edgemont ores was quite low, the initial mill flow sheet did not include a circuit for recovery of this constituent. However, the presence of vanadium was recognized as a potential value, and long-range planning, plus AEC contract requirements, necessitated that the vanadium-enriched slime tailings be impounded separately from the sand tailings for possible future treatment. In 1960, additions were made to the plant to recover vanadium as a final product from the current slime tailings and from the previously impounded slimes. This addition resulted in increased revenue from the mill for the previous owner, MDI.

From 1960 until about mid-1967, only slime tailings were processed for vanadium recovery. In 1967, MDI added another vanadium circuit designed to process 25 tons of ore per day of metallurgical slags from Europe containing 12 to 15 percent V_2O_5. This circuit was also used to treat vanadium-bearing fly ash and spent catalysts.

During the period of time when the AEC was purchasing uranium (1956-1968) from MDI, a total of 3,426,695 pounds of V_2O_5 were produced from ore slimes in the form of a high-grade (99 percent V_2O_5) "black flake." At that time, the V_2O_5 production from slimes was about one-half pound V_2O_5 for every pound of U_3O_8 produced. All vanadium production was sold commercially. No data are available on the vanadium production from ores after 1968, or from the slags, etc., from late 1967 until the plant shut down in 1974.

Molybdenum was also recovered as a byproduct during the 1963-1967 period when uraniferous lignite ash was processed. This was necessary to avoid excessive contamination of the uranium concentrates with molybdenum, i.e., to meet AEC concentrate specifications. The calcium molybdate product was sold commercially. No data are available on the quantity of molybdenum (Mo) recovered but it is estimated at about 100,000 pounds.

All of the structures remain on-site with most of the processing and operational equipment still in place. The main mill building is a steel-framed, galvanized-metal-exterior structure of about 40,000 square feet. There are an additional 12 buildings, shops, warehouse, office, etc. The total area in all these buildings is about 1.2 acres. Since plans are to decommission the facility, there will be no further ore processing to add to the tailings.

PROCESS DESCRIPTION AND MAJOR CHANGES

The initial flow sheet at Edgemont consisted of ore crushing and grinding, agitation leach with sulfuric acid, countercurrent washing of the sands in classifiers, and treatment of the minus-300 mesh slime pulp in the resin-in-pulp (RIP) process. The uranium-loaded resin beads were eluted with a nitrate solution from which the uranium was precipitated. Concern over possible nitrate contamination of surface and ground water prompted MDI to install the Eluex process in 1958. Eluex enabled MDI to elute with sulfuric acid and to recover the uranium from this solution by means of solvent extraction. Eluex also effected a savings in chemical consumption and permitted recycle of raffinate together with the benefits of a higher grade product.

Although the Edgemont mill treated carnotite-type ores containing about as much vanadium as uranium, vanadium recovery was not instituted until 1960. Later additions to the vanadium circuit enabled MDI to handle a variety of vanadium-bearing materials, including an iron slag imported from Europe.

Uraniferous lignite ash, derived from field burning of lignites, constituted up to 10 percent of the millfeed during the 1963-1967 period. While treating lignite ash, MDI also recovered the solubilized molybdenum as a byproduct. The ash contained considerable amounts of clay, iron, residual organics, and acid-consuming minerals which complicated processing.

The AEC paid the miners and MDI for the vanadium in the ore that constituted the early feed for this mill. Hence, MDI was required by the AEC to neutralize with lime the resin-in-pulp slime tailings, which contained about 80 percent of the vanadium originally present in the ores, and to impound the precipitated vanadium and tailings slimes separately from the tailing sand fraction. The slimes constituted 10 to 20 percent of the weight of the ore, were essentially the minus-300 mesh solids, and contained about 0.9 percent V_2O_5 on a dry-weight basis. In 1960, when MDI commenced vanadium recovery, the slimes no longer were neutralized but were taken directly to vanadium leaching. Beginning in 1962, the earlier neutralized slimes were also repulped and leached for vanadium recovery. MDI used a system of ponds in place of conventional thickeners for separating the pregnant vanadium liquor from the solids. It was this vanadium recovery scheme that added to the number of ponds at the Edgemont mill, not the uranium recovery.

The various process changes described above had little effect on the characteristics of the tailings. The method of tailings impoundment remained unchanged since plant start-up, but tailings, both sands and slimes, have been moved about considerably throughout the life of the operation. There is very little residual uranium or other values in the tailings so that reprocessing appears unattractive. Testing of slime ponds by Solution Engineering, Inc., a few years ago showed that uranium recovery would require a price of $50 or more per pound to be economic.

SITE DETAIL

LOCATION

The Edgemont uranium mill and tailings are located on the east side of Edgemont, Fall River County, in southwest South Dakota. The site is 13 road miles east of the Wyoming-South Dakota border; 27 miles southwest of Hot Springs, the county seat; and 85 miles southwest of Rapid City. Portions of the site are within the eastern extremities of the city of Edgemont corporate limits. This site is located on the Cheyenne River at the mouth of Cottonwood Creek, which traverses the western portion of the site.

The TVA property consists of some 213 acres, of which about 123 acres are tailings deposited in 11 distinct disposal areas. The site is rectangular, extending about 5100 feet in the north-south direction and about 3400 feet east-west in the widest part. Burlington Northern Railroad right-of-way forms the western border of the site. Adjacent to the northeastern property line is a large (800 feet x 1200 feet) city sewage pond. Figures 1 and 2 show the relationship of the mill and tailings to Edgemont, Cottonwood Community, and other local geographic features.

TOPOGRAPHY

The topography of the Edgemont area is characterized by flat bottom lands, alluvial terraces, and gently rolling hills. Elevations at the millsite range from 3500 feet at the southeastern corner of the site to about 3420 feet along the Cheyenne River. To the north are gently rolling hills followed by rugged northwest-southeast trending ridges. South of the site are relatively broad, flat bottom land and alluvial terraces. The millsite topography is shown in Figure 3.

Vegetation in the area is primarily grass and sagebrush with native pine in scattered locations on the higher hills and cottonwood trees along natural waterways.

CURRENT CONDITIONS OF TAILINGS

The tailings have been distributed in 11 distinct disposal areas. Since acquiring the site, TVA has performed considerable site remedial work including (1) contouring, covering with top soil, and seeding of the East pile to prevent wind erosion, (2) retrieval of windblown tailings off-site to the east which were placed in Ponds No. 7 and 9 and then seeded, (3) covering and seeding of Pond No. 4, (4) strengthening of dikes, and (5) erection around the perimeter of a 6-foot chain link fence with three strands of barbed wire on top. The site appears well maintained, and an excellent cover of vegetation has been established on all the sand tailings piles and on those ponds that have been covered. The uncovered ponds do not appear to be a problem because of trapped water that keeps the bottom surfaces moist.

QUANTITIES

There are approximately 2,034,000 tons of tailings (sands and other residues) impounded at the Edgemont site. The tailings resulting from production of uranium for sale to the AEC amounted to 1,622,000 tons or about 80 percent of the total tailings. Residues from vanadium production, included in the above total, are estimated at 45,255 tons.

Since the mill is to be disassembled for possible equipment salvage, there is virtually no possibility of additional tailings being added to the present commingled tailings. The quantities then are static. Off-site cleanup of tailings and contaminated soil may add a few thousand tons to the total already on-site.

TAILINGS MANAGEMENT HISTORY

The initial AEC contract required separate impoundment of the slimes along with the vanadium precipitated by lime neutralization of the resin-in-pulp slime tailings. Hence, Ponds No. 1 and 2 were used for that purpose between 1956 and 1960. Although Pond No. 3 was built in 1958, it was not used until all ore that contained vanadium paid for by the AEC had been processed. After that, MDI was at liberty to combine the sand and slime if desired. MDI opted to continue the separate impoundment of sands and slimes because it facilitated the vanadium recovery that commenced in 1960. Initially, MDI processed only slimes from current operation, but in 1962 MDI also began excavating and processing slimes from Ponds No. 1 and 2 at a rate of 100 to 150 tons per day. The slimes, after strong acid leaching, were pumped to Pond No. 3. As the slimes settled, they were pumped from Pond No. 3 to Pond No. 7. Solution flowed countercurrent from No. 7 to No. 3 to No. 4; thus the ponds were used for washing slimes in place of conventional thickeners.

The above-described ponds, as well as others built later, had additional and varying usages as described in Table 2. The sand tailings, constituting 80 to

90 percent of the weight, were relatively easy to impound and were too low grade to merit retreatment for residual values.

Table 2. Description of Tailings Piles and Pond Contents, Edgemont Uranium Mill

Tailings Pile and/or Pond	Description
Sand Tailings Area A	Built in 1956; used until 1961; now stabilized with excellent vegetation.
Sand Tailings Area B	Built in 1958, partially filled with sand.
East Sand Tailings Pile	Used from 1961 to 1967; TVA contoured, covered, and seeded in 1975; excellent vegetation.
Pond No. 1	Built in 1956; used for slime tailings 1956-1957; now sands and slimes.
Pond No. 2	Built in 1958; used for slimes 1958-1962; now sands and slimes, with stabilization cover and vegetation.
Pond No. 3	Built in 1958; used as described in text for vanadium recovery; now slimes.
Pond No. 4	Built in 1961; used as described in text; windblown tailings from East Sand Tailings Pile nearly filled pond before it was covered and seeded; good vegetation cover.
Ponds No. 5 and 6	Never used but contain some windblown tailings from East pile.
Pond No. 7	Built in 1961; used for slimes as described in text; sands added 1971 and 1972; in 1975, off-site windblown tailings were placed in pond prior to covering and seeding; excellent vegetation.
Pond No. 8	Built in 1969; used for slimes and vanadium residues; not covered.
Pond No. 9	Built in 1970; used for slimes, vanadium residues, and off-site tailings cleaned up in 1975; covered and seeded; excellent vegetation.
Pond No. 10	Built in 1971; used for raffinate solution for storage only, no tailings.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

Edgemont had a 1980 population of approximately 1500 while Cottonwood Community, south of the millsite and west of the ponds, has a population of about 75. North of the site across the Cheyenne River is a small residential area known as Dudley with a population of about 60. Population in the area has fluctuated dramatically in the past depending upon employment opportunities. For example, in the 1950s and 1970s, the population of Edgemont doubled because of expanding energy-related developments. In the 1960s, there was a significant population decrease due to the closing of the nearby Army Ordnance Depot, and in 1980 due to decreased railroad-related employments.

WATER

One of the environmental concerns at Edgemont is the possible contamination of surface and ground waters. The average annual precipitation in the area is only about 14 inches so most streams are ephemeral. All streams flow into the Cheyenne River which begins about 115 miles west of the millsite. It flows from east to west along the northern boundary of the site and drains a 7140-square-mile area above Edgemont. The average annual flow at Edgemont is 97 cubic feet per second (cfs) and has ranged from a low of 13 to a maximum of 434 cfs. During periods of high spring flow, the river channel is filled to a depth of 7 to 10 feet.

Cottonwood Creek, which flows through the millsite, drains an area of about 150 square miles. No historical flow records are available for Cottonwood Creek, but TVA estimated it to average 2.3 cfs.

Flood stages of the Cheyenne River and Cottonwood Creek can reach the level of the base of the tailings ponds in some areas. Hence, it has been concluded that physical transport of tailings due to flooding of either the river or the creek is possible.

Ground water in western Fall River County occurs both in unconsolidated sediments and in bedrock aquifers. Unconfined ground water occurs beneath the existing tailings site in unconsolidated Quaternary alluvial deposits ranging up to 30 feet thick. Extensive intertonguing of sediments from the Cheyenne River alluvial floodplain and Cottonwood Creek exists beneath the tailings site. Water from the alluvium is of poor quality with high concentrations of sodium, magnesium, sulfate, and bicarbonate. Nevertheless, the alluvium is used locally as a water source for domestic and stock water supplies. Waters from the deeper aquifers in the Fall River and Lakota Formations are only fair to very poor, but are also used for domestic, irrigation, and livestock purposes.

Water standing in the tailings ponds is acidic and contains high concentrations of dissolved solids, sulfate, cadmium, chromium, iron, nickel, titanium, and vanadium. Leachates migrating from the ponds and tailings piles are a potential source of contamination of the alluvial aquifer, the creek, and the Cheyenne River near the site. Ground-water samples taken directly beneath the site are contaminated with leachates, and ground water passing under the site picks up considerable contamination as evidenced by the increased concentrations of dissolved solids.

AIR

Another environmental concern at Edgemont is the exhalation and transport of radon gas from the tailings and windblown tailings that might be inhaled. Radon gas concentrations above background levels have been detected up to 0.7 mile from the site. TVA plans to move the tailings to an isolated area away from Edgemont.

Regional winds tend to be most frequently from the west-northwest and secondarily from the east-southeast. Wind speeds are relatively high, especially in the spring, with a mean of 10.7 miles per hour. Thunderstorms are frequent during the summer months and are generally accompanied by extreme winds of short duration. Tornadoes are infrequent in western South Dakota with a mean recurrence interval for a tornado at any point within the Edgemont area of about 1650 years.

SURFACE CONTAMINATION

The surface areas contaminated by the uranium milling activities at Edgemont include those beneath the tailings, solution ponds, ore stockpiles, the mill, and wherever windblown tailings or other radioactive particulates may have settled. Extensive surface radiation monitoring and soil sampling will determine the exact magnitude of this problem as part of the decommissioning and tailings disposal plan proposed by TVA. During the course of the project, Cottonwood Creek will have to be diverted and contaminated materials from the channel removed. TVA has retrieved the windblown tailings from the off-site area to the east and has covered those piles previously subject to wind erosion.

DISCUSSIONS OF VIABLE STABILIZATION OPTIONS

In preparing its decommissioning plan, TVA considered the alternative of in-place stabilization, but agreed with the NRC that such action might not mitigate some of the environmental problems associated with the present site. The plan proposed by TVA to the NRC envisions moving all tailings and contaminated subsoil to a location about 2 miles southeast of the present site. TVA has estimated the cost of its decommissioning and tailings disposal project at $20 to $30 million (1979), and estimates it will require 7 years to complete.

Similarly, Ford, Bacon and Davis Utah, Inc. (FBDU), in its 1978 engineering assessment report, considered in-place stabilization, consolidation prior to stabilization, and removal to four different sites ranging from 2.5 to 12.4 miles away. FBDU estimated costs ranging from $6.11 million for decommissioning and in-place stabilization to $18.97 million for removal to a site 12.4 miles away. For use of a site 2.5 miles away, FBDU estimated a cost of $10.79 million, or somewhat less than TVA's estimate. The main difference in estimates is attributable to the amount of subsoil that may require excavation and transport to the disposal site.

The NRC, in its DES, considers alternatives for (1) millsite decommissioning, (2) tailings disposal both on-site and off-site, (3) disposal impoundment designs, (4) clay liners, and (5) waste transportation methods. The NRC concluded on-site stabilization is unacceptable because of the proximity of Edgemont and the probability of tailings impoundment erosion over the long term. The NRC considered TVA's proposed plan as generally satisfactory.

Off-site vicinity properties radiation surveys and remedial action costs in Edgemont could amount to as much as $2 million, depending on the number of properties requiring removal of tailings.

DISCUSSION OF PROPOSED COST-SHARING PLANS

At the time of the site visit on November 3, 1981, TVA representative Dr. Thomas Donovan expressed satisfaction with a simple factor of the tonnage of tailings resulting from production under the AEC contracts to the total tonnage of tailings at Edgemont. The factor could be applied to the cost of the decommissioning and tailings stabilization. TVA had no suggestions for a more equitable cost-sharing arrangement. However, in keeping with the proposed concept of adjusting the quantity of tailings attributable to the AEC contracts for production of byproducts during the terms of the AEC contracts, the factor, on a tonnage basis, would be reduced from about 80 to about 74 percent. This adjustment is for vanadium only, not molybdenum which had to be removed anyway from process control purposes.

TVA has expressed disagreement with the concept of adjusting the tailings quantity attributable to the AEC contracts for byproduct vanadium production at Edgemont, especially since the tailings resulted primarily from contracted operations to supply uranium to the AEC. Also, TVA's position is that any equitable cost-sharing arrangement should include consideration of previous expenditures when a tonnage factor is applied, and urged that this be included as a recommendation to Congress.

REFERENCES

"Draft Environmental Statement Related to the Decommissioning of the Edgemont Uranium Mill," U.S. Nuclear Regulatory Commission, NUREG-0846, September 1981.

"Edgemont Uranium Mill Decommissioning Plan Environment Report," Tennessee Valley Authority, February 26, 1979.

"Engineering Assessment of Inactive Uranium Mill Tailings, Edgemont Site, South Dakota," Ford, Bacon & Davis, Utah, Inc., prepared for the USNRC, May 1978.

TVA letters and reports submitted to Dr. William E. Mott, U.S. Department of Energy, Washington, D.C., on March 6, April 20, and August 11, 1981.

FIGURES

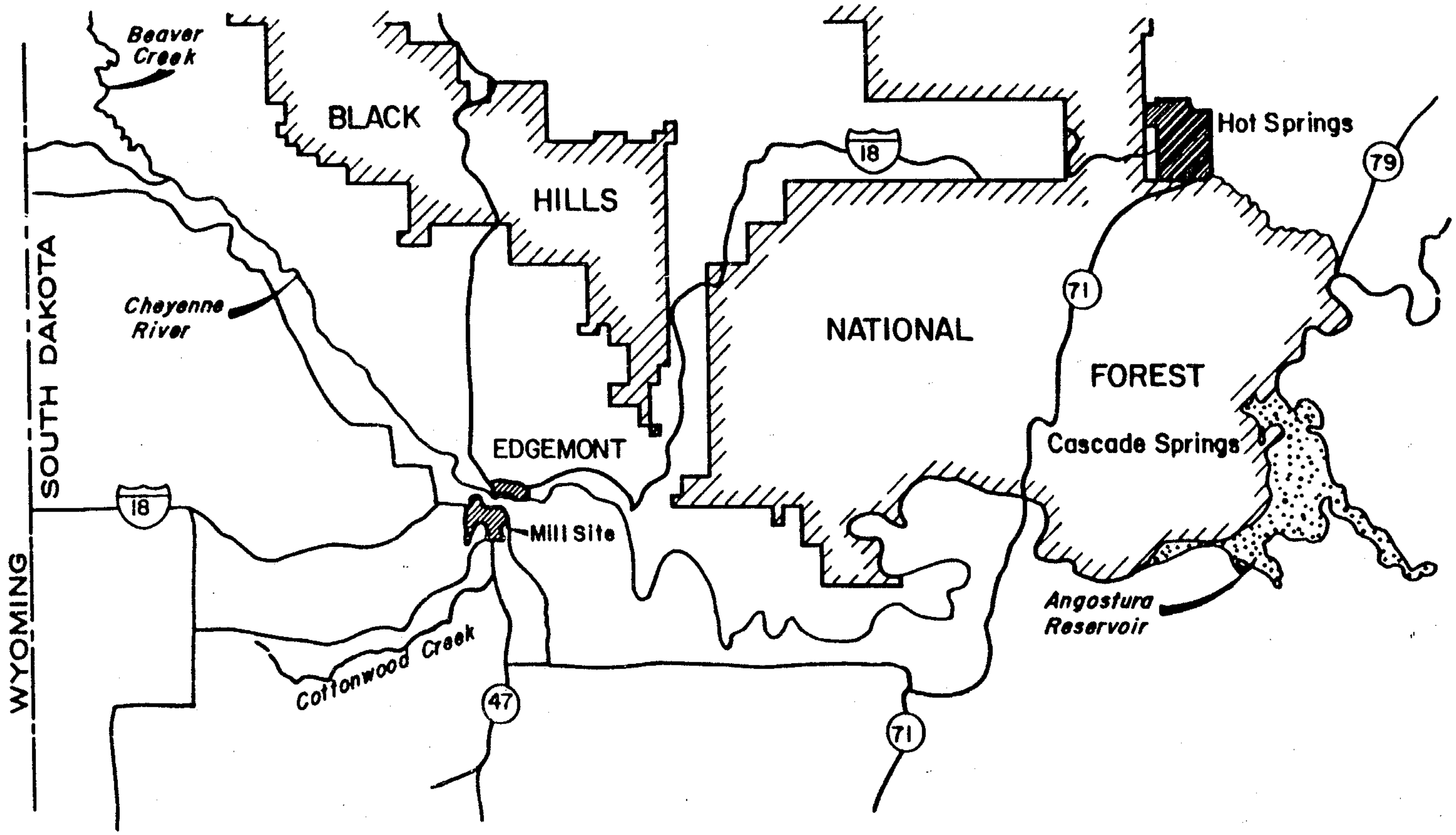

Figure 1. Location Map: TVA Millsite and Tailings, Edgemont, S. Dakota

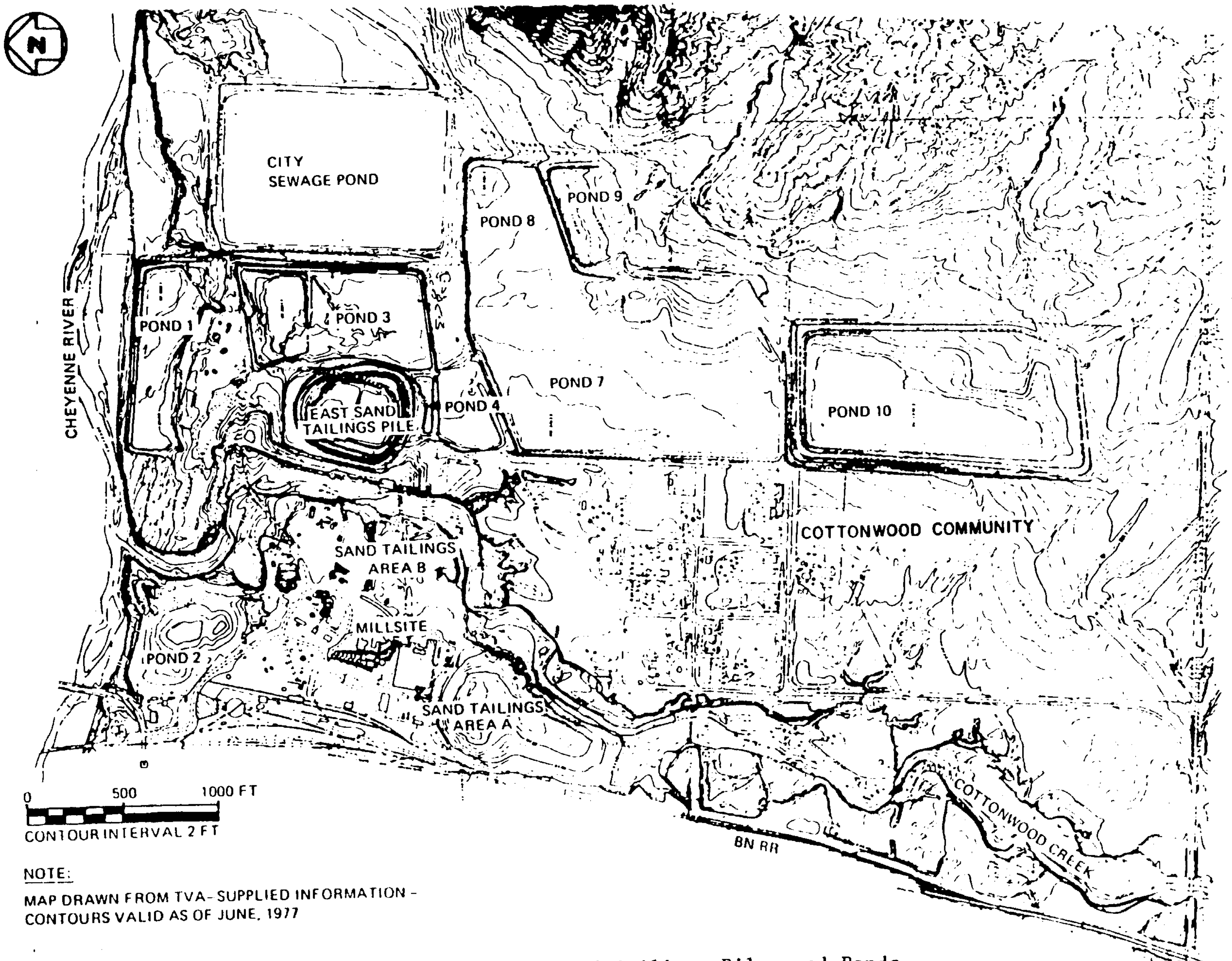

Figure 3. TVA Millsite and Tailings Piles and Ponds

SITE REPORT: ATLAS MINERALS
Moab, Utah

INTRODUCTION

In June 1955, the AEC entered into a uranium procurement contract with the Uranium Reduction Company (URC) for the production from a mill to be located near Moab, Utah. A mill capable of processing ore at a nominal rate of 1500 tons per day was constructed and began operations late in 1956. The site selected by URC for the mill is adjacent to the Colorado River and was close to the Government's uranium ore-buying station where the AEC had purchased and stockpiled about 688,000 tons of ore. As provided in the contract, this ore was sold to URC by the AEC. In 1962, URC was acquired by Atlas Corporation and operations have since been conducted by the Atlas Minerals Division.

The mill has operated almost continuously since start-up, and all tailings have been impounded in one disposal area. Uranium production until about 1967 was exclusively for the AEC; after that Atlas began selling to both the AEC and to commercial buyers. During the terms of the AEC contract (calendar years 1956-1970), only about 7 percent of the production was sold commercially. Since 1970, all production has been for the commercial market. Hence, the tailings in the only impoundment at Moab are commingled, with the tailings attributable to the AEC contract situated at the bottom portion of the pile.

Additionally, Atlas prepared a report for the American Mining Congress Uranium Commingled Tailings Subcommittee that was given to the DOE. That report and supplemental information obtained from Atlas personnel were helpful in the preparation of this site report.

BACKGROUND AND HISTORY

OWNERSHIP

The Moab, Utah, mill, tailings pile, solution ponds, and related facilities are situated on approximately one-half of the 400-acre property owned by Atlas Minerals Division of the Atlas Corporation. The mill was constructed and operated initially by Uranium Reduction Company and became wholly owned by Atlas in 1962.

The original source materials license for operation of the Moab mill was issued by the AEC in 1956. The Nuclear Regulatory Commission (NRC) is now the licensing and regulatory authority, since Utah is not an Agreement State. The current Atlas license is due to expire April 30, 1984.

PRODUCTION HISTORY

The 1500-ton-per-day mill at Moab began operations in October 1956 and produced uranium for sale to the AEC through December 1970. On July 31, 1963, Atlas acquired another uranium mill, the one at Mexican Hat, Utah, and operated it through its subsidiary, A Z Minerals, until February 28, 1965. Uranium produced at Mexican Hat, after Atlas became the operator, was delivered to and purchased by the AEC under the Atlas-Moab contract as shown below:

AEC Contract No.	Period (CY)	Mill	AEC Purchases	
			U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-266	1956-1970	Moab	38,500,282	--
AT(05-1)-266	1963-1965	Mexican Hat	1,742,406	--
Totals	1956-1970		40,242,688	$8.07

The Mexican Hat mill was built by Texas-Zinc Minerals Corporation and was operated by that company from the initial operation in late 1957 until acquired by Atlas. The mill was built on land leased from the Navajo Nation and, after the Atlas lease expired in 1970, control of the site, including the buildings and tailings, reverted to the Navajo Nation.

During the period of operation under the AEC contract, the Moab mill processed ores at an average rate of about 1400 tons per day, and treated a total of 6,393,389 tons of ore containing an average of 0.34 percent U_3O_8. Recovery of uranium was excellent and averaged about 95 percent. Residual U_3O_8 in the tailings amounted to only 0.015 percent, not enough to make reprocessing of tailings attractive.

As noted earlier, during the period of operation under the AEC contract, 93 percent of the uranium production was delivered to the AEC. Sales of uranium in the commercial market commenced, at a very small scale, about 1967. By 1969, Atlas' commercial sales equaled that purchased by the AEC. As AEC purchases declined, more uranium was sold commercially.

In 1967, Atlas constructed a vanadium recovery circuit at Moab for processing uranium-vanadium ores. That circuit started in June 1967 and operated for about 18 months before a fire destroyed the solvent extraction circuits for both uranium and vanadium recovery. During this brief operating period, the following quantities of vanadium were produced:

Calendar Year	V_2O_5 (lbs.)
1967	291,352
1968	963,259
Total	1,254,611

Hence, during the term of the AEC contract, 1,254,611 pounds V_2O_5 were produced as a byproduct at Moab.

Also, for a few years (1966-1968) following shutdown of the Mexican Hat mill, the uranium-copper ores previously treated at that mill were delivered to Moab for processing. Some of the equipment from the Mexican Hat copper circuit was moved to Moab and other equipment was added. The copper circuit at Moab was operated whenever sufficient ore (about 10,000 tons) had been accumulated. The ore was campaigned, and then the circuit was shut down pending deliveries of additional copper-bearing uranium ores. The total amount of byproduct copper recovered at Moab is not known, but the maximum annual production has been estimated at about 100,000 pounds of copper in a copper sulfide flotation concentrate along with some cement copper. Actual copper production for calendar year 1966 was only 37,600 pounds. This product, containing 20-25 percent copper, was shipped to a copper smelter. Production lasted only a short period of time because these ore deposits were soon depleted.

In 1964, Atlas signed an AEC stretch-out contract modification that deferred deliveries of 3.2 million pounds of U_3O_8 from the 1963-1966 period until 1967-1968. During 1969 and 1970, the AEC agreed to purchase uranium equal to the amount of pounds deferred.

The recent depressed uranium market caused Atlas to lay off about one-third of its work force in January 1982. Some mines have been shut down, others put on standby, and mill production has been curtailed. However, Atlas officials remain optimistic about the long-term future of the Moab operation.

PROCESS DESCRIPTION AND MAJOR CHANGES

The Moab, Utah, mill has undergone several major changes in process since it began operation in October 1956. The milling process initially used was the sulfuric acid leach resin-in-pulp (RIP), followed by nitrate elution of the resin and precipitation of the uranium with ammonia.

Then, as the lime ($CaCO_3$) content of ores tributary to the mill increased, the mill was converted in 1961 to an alkaline-leach RIP process. In this process, the uranium was solubilized in a sodium carbonate-bicarbonate solution. Following adsorption on the resin beads, the uranium was eluted with a solution of sodium chloride and sodium bicarbonate. The eluate was heated and acidified to remove carbon dioxide; then the uranium was precipitated with magnesium oxide.

In 1967, Atlas installed an acid leach solvent extraction process to recover both uranium and vanadium. Shortly thereafter, the alkaline circuit was modified to precipitate the uranium directly from a clarified leach liquor, thus abandoning the RIP operation which had become obsolete and expensive to operate.

A year or so after the 1968 fire that destroyed the solvent extraction circuits, they were rebuilt. The combined acid and alkaline circuits give the Moab mill greater flexibility for handling a variety of ores as compared to most other mills.

There is no mine at the millsite; all ore is hauled by truck from the many mines (20 to 70) that the mill serves. The average haul distance is about 50 miles.

Atlas also operated intermittently at Moab a small flotation circuit to recover copper from copper-bearing uranium ores. The sulfide concentrate had to be acid leached to extract the uranium prior to shipment to the smelter.

The use of these various milling processes has affected to some extent the characteristics of the solid tailings produced during the life of the operation. For example, during the initial operation of the acid leach RIP process, it was necessary to neutralize the tailings with ground limestone, using about 65 tons per day. When the alkaline-leach process was adopted, a finer grind was required for successful uranium extraction.

SITE DETAIL

LOCATION

The Atlas uranium mill and tailings are located about 3 miles northwest of the city of Moab, Grand County, Utah, as shown in Figures 1 and 2. The Atlas property is located in Section 27, T. 25 S., R. 21 E., Salt Lake B.M., and consists of approximately 400 acres bounded on the north by U. S. Highway 163 and on the southeast by the Colorado River. Property boundaries extend across Utah Highway 279 on the west and southwest sides. The millsite and tailings pile currently occupy about 70 and 130 acres, respectively.

TOPOGRAPHY

The mill and tailings pile are situated in the northernmost portion of a long, narrow valley trending northwest-southeast as shown in Figure 3. The valley is an elongated, elliptical depression extending from northwest of the Colorado River to about 15 miles to the southeast. The valley floor is at an elevation of about 4000 feet, and the walls of the valley near the tailings piles rise steeply about 1000 feet. The southernmost boundary of the Arches National Park is immediately north of the Atlas property.

CURRENT CONDITIONS OF TAILINGS

As shown in Figure 3, the Atlas commingled tailings pile occupies approximately 130 acres with the top surface of the pile covering some 80 acres. Currently, the crest of the dike has an elevation of 4058 feet. Because the impoundment is on a sloping surface, the embankment height varies from as little as 4 feet above the natural ground surface near the northwest corner, to approximately 100 feet along the east side. The configuration of the tailings pile at various times during the life of the operation is depicted by the generalized cross sections shown in Figure 4.

The tailings pile is expected to reach a final elevation of 4076 feet, 18 feet higher than at present, with construction during 1982 of new perimeter dikes. The pile height then will vary from about 20 feet to 120 feet.

Since the sloping sides of the pile consist of red dirt and rock from nearby excavations, the pile blends well with the natural features in the area.

The tailings are pumped to the top of the pile as a slurry (solids and water) and discharged around the perimeter by use of spigots. The finer particles (slimes) tend to flow toward the center where they settle. The solids-free decant solution is returned to the mill for reuse. The uppermost surface of the pile is moist and is prevented from drying out by changing the discharge periodically and by sprays. Chemical dust suppressants are also used as necessary.

QUANTITIES

During the period of the AEC contract (1956-1970), a total of 6,393,389 tons of ore was fed to process in the Moab mill. There were 41,477,839 pounds of U_3O_8 produced, and the AEC purchased 38,500,282 pounds, or 93 percent of the total. Assuming that 1 ton of ore fed results in 1 ton of tailings (solids), then the tailings attributable to production under the AEC contract would be 93 percent of the ore fed or 5,946,000 tons.

However, a recent analysis by Atlas indicates that 1 ton of ore fed to process at Moab probably resulted in an increased weight of tailings due to acid neutralization, chemical additions, and conversion of lime to gypsum. The increase in weight was estimated at about 3 percent. On the other hand, another mill owner contends the weight of tailings is 3 to 6 percent less than the ore depending on the process used. Recognizing that there may be either gains or losses, it has been decided, for the sake of uniformity, to assume for the purposes of this study that the quantity of tailings are equal to the quantity of ore fed.

Table 1 shows the amount or quantity of tailings at the end of specific periods of time along with estimates of the areas covered and approximate depths of tailings. As of January 1, 1982, the tailings resulting from production of uranium for sale to the AEC constitute 58 percent of the total commingled Atlas tailings at Moab. Each year the percentage will decrease so that by the time the pile is stabilized AEC tailings might amount to only about 50 percent of the total. Also shown in Table 1 is the total area of six small commingled solution tailings ponds plus a ditch to the river, all used during the AEC contract period and still contaminated.

Table 1. Amount of Tailings and Size of Pile at Atlas Minerals at Various Dates

	1/1/71	1/1/82	1/1/92[a]
Tailings (tons)			
AEC Contract	5,946,000	5,946,000	5,946,000
Commercial sales	448,000	4,219,000	6,219,000
Totals (rounded)	6,394,000	10,165,000	12,165,000
AEC Percent of Total	93	58	49
Tailings Pile (acres)			
Total Area	118	128	132
Pile/Pond Surface	92	88	83
Pile Height (feet)	0 - 75	4 - 100	20 - 120
Other Solution Ponds (acres)	3	3.	3

[a]Possible shutdown for start of decommissioning and tailings stabilization. Based on 10 years operation after January 1, 1982, at an annual milling rate of 200,000 tons of ore, a highly speculative rate and subject to change.

TAILINGS MANAGEMENT HISTORY

As previously mentioned, all liquid and solid effluents are now impounded in one tailings pond, and are not permitted to be released from the mill facility. The method of tailings dike construction has changed somewhat in that, during early operations, Atlas was permitted to form dikes from the tailings to raise the height above the original earthen and rock dam. Eventually this practice was stopped and all dikes are now composed of compacted dirt and rock. The manner of tailings discharge by multiple spigots around the periphery has been used throughout the life of the mill. The pond or accumulated water is kept to the center of the pile for decanting, thus protecting the dikes against accidental overflow and dike failure. In addition to the tailings pond, other small ponds within the plant boundary are used for water evaporation and to contain any large spills from the milling operation.

The recycle of tailings pond water, plus the use of sprays for evaporation, now enables Atlas to operate without a solution disposal problem. During earlier operations, excess tailings solution and plant effluents were released to the river after treatment with barium chloride to precipitate soluble radium. Precipitated radium was settled in two ponds and periodically was scraped from the pond bottoms and deposited in the tailings pile. Discharge to the Colorado River stopped in July 1977.

As noted in Table 1, there are six small solution ponds that have been used in the past and are still available if needed. The ponds were used for radium removal, plant spills, and draining of the tailings slurry line, and will require cleanup when the site is reclaimed. The ditch to the river will also require cleanup.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

Moab is the only nearby incorporated community and had a 1980 population of 5340. Including the unincorporated privately owned areas surrounding the town, the total estimated 1980 population within a 10-mile radius of the mill was 6300. The full-time resident closest to the Moab mill, an employee of the National Park Service, lives 1-1/4 miles away. The next closest resident lives 1-1/2 miles away in the city of Moab.

AIR

Airborne effluent releases from the Atlas milling operations are the same as with other uranium mills; namely, radon emissions from the ore storage and tailings piles, and the blowing of dusts from tailings if permitted to become dry. Levels of radioactivity in the air have been monitored by Atlas both on-site and off-site for many years. While radon levels are high just above the ore and tailings pile, ranging from 8 to 66 pCi/l, the radon disperses rapidly and is not considered a health hazard to the public.

Because the climate at the site is semiarid, with only about 8 inches of precipitation a year, the tailings sometimes require wetting by sprinklers and the use of chemical dust suppressants (Coherex) to prevent dusting. The prevailing wind direction is westerly to southwesterly and average wind speeds are quite low so airborne particulates are not scattered widely. A detailed radiation survey performed in 1979 and particulate air sampling in the off-site areas indicate no significant potential health impact from inhalation of airborne particulates.

WATER

The mill is located on the Colorado River terrace a few hundred feet northwest of the river. It is the major surface water stream in the region and has an average discharge (1911-1970) of 7711 cubic feet per second (cfs). The record maximum and minimum discharges are 76,000 and 558 cfs, respectively.

The Moab Canyon Wash, a highly intermittent stream, drains about 8 square miles to the northwest of the site. It cuts across the site, passes the northeast corner of the tailings dike, and runs between the tailings pile and the mill.

The alluvial sediments in the Moab Valley range to 360 feet, average 70 feet thick, and are the most highly utilized aquifer in the vicinity of the mill. On either side of the Colorado River, the water table slopes toward the river with a gradient of about 100 feet per mile. At the site, the slope decreases to approximately 10 feet per mile. Recharge from the southeast is from the LaSal Mountains. Recharge to the Moab Canyon area is very low due to the light precipitation and high evapotranspiration. The water table in the vicinity of the mill is influenced by the elevation of the Colorado River.

All private and public ground-water users are located upgradient from the tailings pond. Process water for mill operations is obtained from the Colorado River (about 400 gpm) while the city of Moab supplies domestic (potable) water.

Atlas reported that there has been no significant surface- or ground-water contamination as a result of its milling operation and tailings disposal practices. Periodic sampling and analysis of Colorado River water above and below the mill have given no indication of contaminants reaching the river. Similar sampling of ground-water wells between the tailings area and the river has shown insignificant migration of radionuclides and nonradiological chemicals used in the mill.

SURFACE CONTAMINATION

The extent of on-site surface contamination, except under the tailings, will be assessed by Atlas at the time of decommissioning. The off-site surface contamination, especially that due to windblown tailings, has been adequately assessed based on the results of the 1979 Ford, Bacon & Davis Utah, Inc., survey and the company's air sampling. It is not considered to be a significant potential health hazard to residents of the Moab area. Atlas advised that a recently completed aerial radiometric survey, performed by EG&G (Las Vegas) under contract to the Nuclear Regulatory Commission, may give additional details as to the presence or absence of windblown tailings in off-site areas.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

Atlas will be required to conduct decommissioning and reclamation activities at the millsite in accordance with conditions of its NRC source material license. A surety agreement was entered into between Atlas Corporation and the Board of Oil, Gas, and Mining of the State of Utah on May 31, 1979, to satisfy an NRC license condition that decommissioning and tailings stabilization will be accomplished.

Atlas has submitted to the NRC a final reclamation plan, one that may be used for bonding purposes. Atlas proposes to reshape the tailings pile so that proposed slopes will be no steeper than 10 feet horizontal to 3 feet vertical. The pile would be overlain by silty fine sand to a uniform thickness of 10 feet, and then either topsoil and vegetation or gravel would cover the outer surfaces.

Atlas estimated the cost of the proposed reclamation (stabilization) plan at $3.3 million (1977 dollars). Additionally, a range of alternatives was considered including removal of the tailings pile to other locations. These alternatives ranged in cost from the $3.3 million to $72 million.

During decommissioning, Atlas will decontaminate process equipment and sell it for reuse or scrap metal. Mill structures will be put to other use, if possible. Otherwise, structures will be removed, foundations leveled, and the entire site decontaminated for release for unrestricted use.

Decommissioning was estimated at approximately $2.3 million, which included the offset of salvage.

Hence, the total estimated cost for decommissioning and tailings stabilization at the present site is about $5.6 million. The costs of alternatives range from the $5.6 million to approximately $75 million.

DISCUSSION OF PROPOSED COST-SHARING PLANS

During the site visits, various approaches to cost-sharing were discussed with Atlas officials. Briefly described they were as follows:

1. Proportionality Based on Tons of Tailings Attributable to the AEC Contract to the Total Tonnage at Decommissioning
   As indicated in Table 1, the tailings attributable to the AEC contract were 93 percent of the total as of the end of the AEC contract, 58 percent at the end of 1981, and would be an even smaller proportion at the time of stabilization and reclamation.

2. Proportionality as in (1) but with Adjustments for Byproducts (V_2O_5 and Cu) Produced During AEC Contract Period
   In this instance, the production of both vanadium and copper at Moab were so small that adjustments would be less than one-half of one percent. Weight gains of tailings calculated by Atlas would more than offset the suggested adjustments for byproducts.

3. Federal Government Share Based on Acreage of Tailings To Be Stabilized
   The acreage of tailings has increased little from the end of the AEC contract; the pile has only become higher. At the time of stabilization, the acreage could be enlarged somewhat depending on the final slope acceptable to regulatory agencies.

Atlas officials favor the area-based option, either the straight proportional approach or as of the end of the AEC contract. They believe that it would be relatively easy to calculate the proportion of acreage as of January 1, 1971, versus the final area covered when stabilization is completed. Atlas officials noted that the major cost of stabilization is related to the surface area, not the tons of tailings in the pile.

Atlas officials also raised questions as to the elements of costs to be included in cost-sharing, noting, however, that they are in general agreement with the "Cost Factors of Interest to Owners," presented and discussed at the AMC/DOE meeting on commingled tailings at Grand Junction on January 21, 1982. Atlas also expressed concern over possible future obligations on the part of Atlas after the tailings have been stabilized and turned over to the United States or the state in which they reside. In conclusion, Atlas is still in the process of determining which cost-sharing approach would be the most equitable and appropriate.

REFERENCES

Atlas Report to AMC, September 8, 1981.

"Final Environmental Statement, Atlas Uranium Mill," NUREG-0453, January 1979.

FIGURES

Figure 1. Location Map

Figure 2. Aerial Photograph (on file at Grand Junction Area Office)

Figure 3. Topographic Map

Figure 4. Generalized Plan Views and Cross Sections

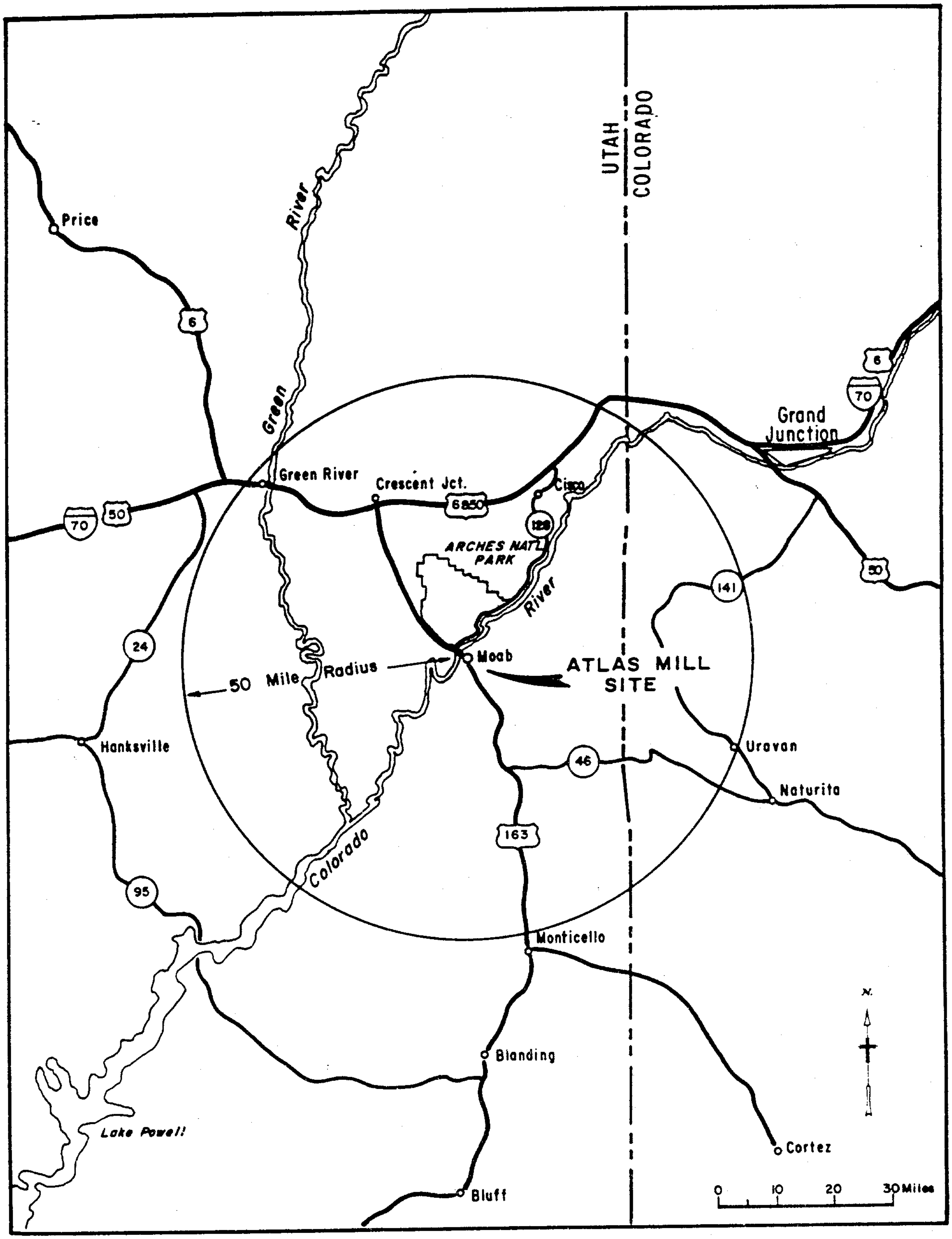

Figure 1. Location Map: Atlas Mill, Moab, Utah (from ER)

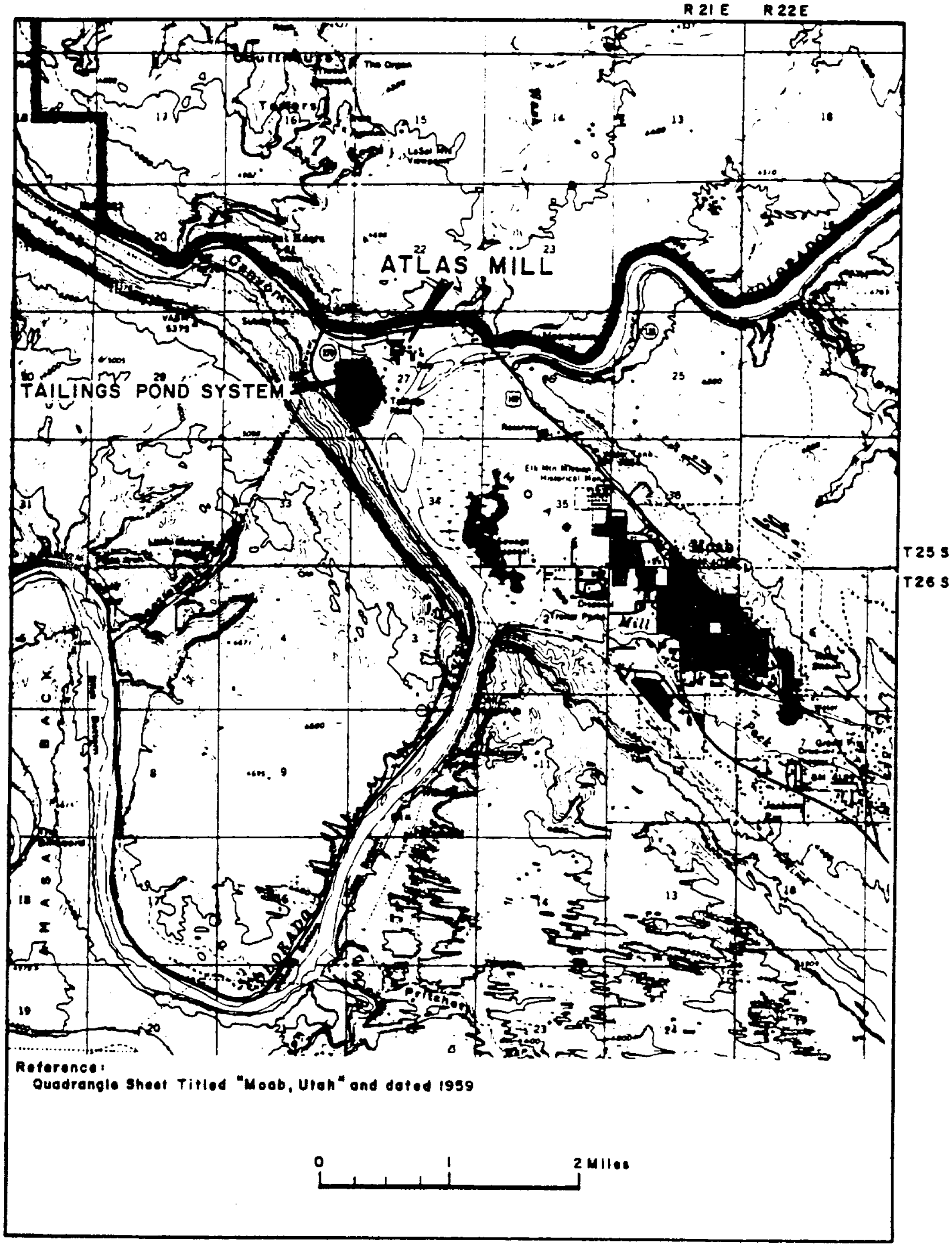

Figure 3. Topographic Map and Historical Features in the Vicinity of the Atlas Mill

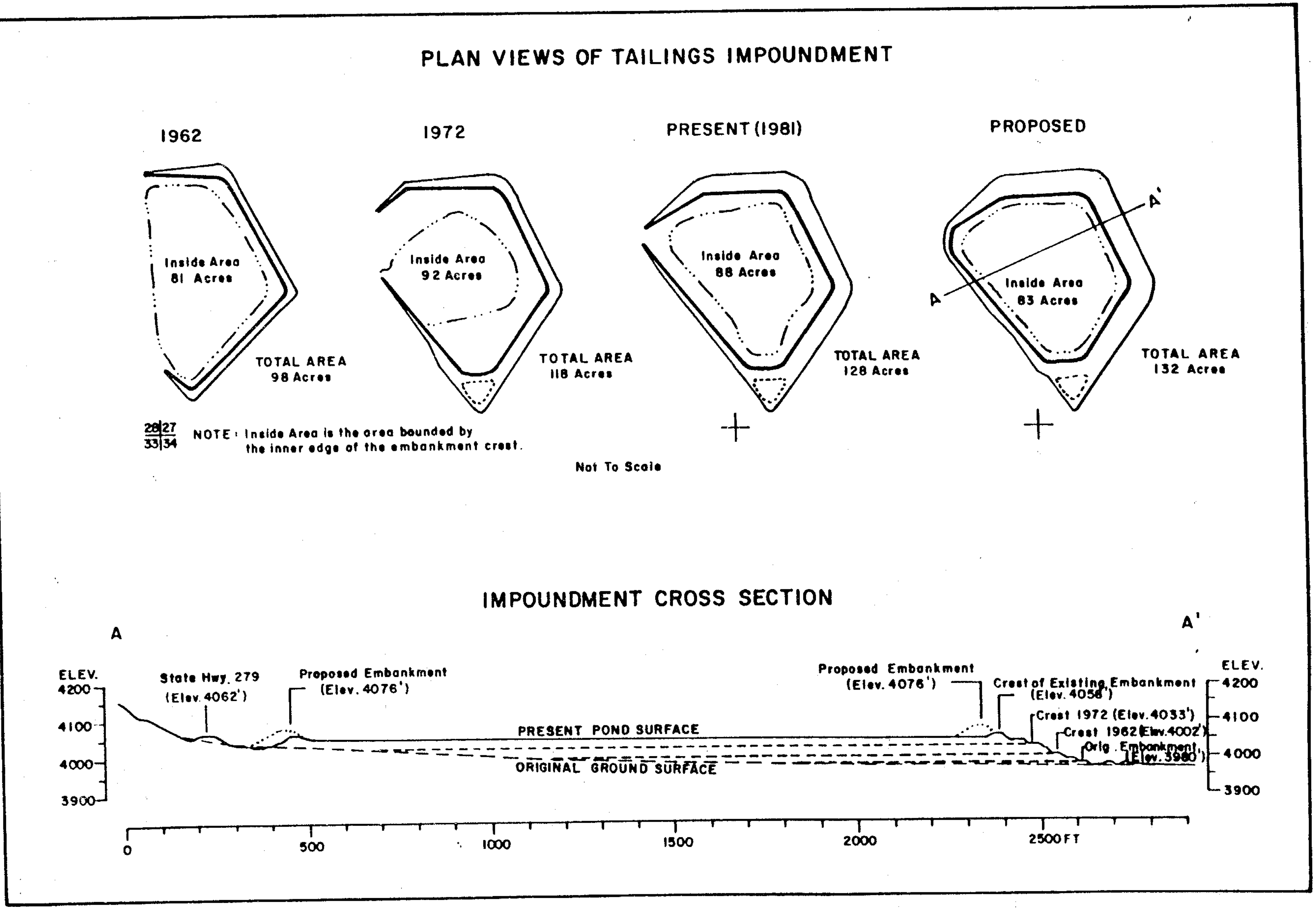

Figure 4. Generalized Plan Views and Cross Section: Atlas Minerals Tailings Impoundment

SITE REPORT: DAWN MINING COMPANY
Ford, Washington

INTRODUCTION

The purpose of this report is to establish the amount and condition of the defense-related uranium mill tailings at the millsite of the Dawn Mining Company, Ford, Washington. This report summarizes data and information provided by Dawn.

BACKGROUND AND HISTORY

OWNERSHIP

The uranium mill and tailings piles near Ford, Washington, are situated on about 500 acres of property owned by the Dawn Mining Company. Dawn, a subsidiary of Newmont Mining Corporation, is owned 51 percent by Newmont and 49 percent by Midnite Mines, Inc. Sixty percent of Midnite Mines, Inc., is controlled by Spokane Indian Tribal members. The ownership of Dawn has remained unchanged during the life of the operation.

The initial source materials license for the operation of the Dawn mill was issued by the AEC in 1957. The State of Washington is an NRC Agreement State and now has regulatory and licensing authority. Application for license renewal was made in July 1979 and renewal should be received by February 1983.

PRODUCTION HISTORY

The mill when built had a nominal capacity of 440 tons of ore per day (TPD), but it now operates at 500 to 600 tons per day or about 180,000 tons per year. The mill started operation late in 1957 and operated until mid-1965 when it shut down. All uranium produced during this period was for sale to the AEC. A total of 5,279,675 pounds of U_3O_8 was purchased by the AEC at an average price of $9.03 per pound. The ore processed during this period amounted to 1,171,313 tons that contained 0.24 percent U_3O_8. Uranium recovery from the ore has always been excellent at the Ford mill and averaged 96 percent during the 1957-1965 period. All tailings from initial production to shutdown, assumed to be equal in quantity to the ore fed or 1,171,313 tons, were impounded in tailings Areas 1 and 2.

Summarized below are data on AEC purchases of U_3O_8 from Dawn Mining Company under Federal contracts:

Contract No.	Period (FY)	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-706	1958-1960	1,510,477	10.81
AT(05-1)-788	1960-1967[a]	3,769,198	8.31
Total		5,279,675	9.03

[a]Last lot delivered December 1966.

The mill started operation again in late 1969 for commercial sales of uranium. When the mill resumed operation, Area 3 was used for impounding the tailings.

Current plans are to continue operation until 1990, and possibly to the year 2000 if there is a market for the uranium. Nearly all the ore for this mill has come from the company's Midnite Mine, located 22 road miles northwest of the mill on the Spokane Indian Reservation. Ore is mined and hauled to the mill in 25-ton truck-trailer rigs only during the warm weather months. Usual practice is to maintain a 1-year supply of ore in stockpile at the mill.

PROCESS DESCRIPTION AND MAJOR CHANGES

The milling process consists of crushing, grinding, two-stage sulfuric acid leach, four-stage CCD, pregnant solution clarification through an anthracite column, and ion exchange for uranium recovery (four columns), followed by elution, two-stage precipitation with lime and ammonia, product thickening, and drying in a steam-heated dryer. The process remained unchanged from start-up until 1980 when installation of new ion-exchange resin enabled Dawn to change from nitrate to sulfate elution. This process change did not alter the characteristics of the tailings except to eliminate the nitrate discharge to tailings.

No byproducts have been recovered at the Ford mill and the small amount of residual uranium in the tailings would be economically unattractive to recover.

SITE DETAIL

LOCATION

The Dawn uranium mill and tailings are located about one-half mile from the small town of Ford, Washington, and about 25 miles northwest of Spokane, as shown in Figure 1. The Dawn property consists of about 500 acres in Sections 24 and 25, T.28N., R.39E., Willamette P.M., and is bounded on the north by Chamokane Creek. The creek is also the southern border of the Spokane Indian Reservation.

The mill complex is located within an open, mature pine forest that shields it from the view of incidental passers-by as well as local residents. The mill area and tailings piles currently occupy about 20 and 133 acres, respectively. Included in the mill area is the ore storage of 13.6 acres.

TOPOGRAPHY

The mill and tailings are located in Walkers Prairie, a northeast-trending valley about 2 miles wide and 15 miles long. The valley is bordered along the northwest by rimrock cliffs of plateau basalts and along the southeast by rounded granitic hills. The valley floor is a flat plain of glacial out-wash deposits. The tailings are impounded on a relatively level terrace of the Chamokane Creek that averages approximately 1740 feet in elevation. The creek is about one-half mile north of the site and has cut through the terrace to form a relatively steep scarp about 100 feet high.

CURRENT CONDITIONS OF TAILINGS

As shown in Figure 2, there are four separate tailings areas and no separate solution ponds. As noted earlier, Areas 1 and 2 were used to impound tailings resulting from production of uranium for sale under AEC contracts. Use of Area 3 commenced when the mill resumed operation in 1969 and was used until mid-September 1981. At that time, Dawn initiated lined subsurface disposal of tailings in Area 4. The tailings areas are shown in the aerial photograph (Figure 3) which is a view to the northeast. The average depth of tailings in Areas 1 and 2 is approximately 10 feet, and in Area 3 about 15 feet.

The general condition of the tailings areas is very good. Wood chips (6 to 12 inches) have been placed on top of Areas 1 and 2, except for about 10 acres in Area 2 that were covered with about 1 foot of dirt during the summer of 1981. From 1 to 3 feet of dirt cover was also placed on top of Area 3 except for the area nearest the dike on the west side where pond water is still present. Dawn is dewatering the Area 3 pond, by siphon to Area 4, and when sufficiently dry to support equipment, Dawn will finish the dirt cover of Area 3. The uncovered area is principally slimes, so several feet of dirt fill may be required to support equipment. Current plans are to finish the dirt cover on all of Area 3 during 1982 to prevent any further windblown tailings.

The tops and side slopes of all dirt dikes have been or will be hydromulched to establish vegetation.

QUANTITIES

Dawn agrees with DOE data that 1,171,313 tons of tailings resulted from production under AEC contracts. These tailings are all impounded in Areas 1 and 2, but the distribution between areas is unknown. Since Areas 1 and 2 are contiguous, the distribution is unimportant. As shown in Table 1, the total tailings impounded at the Ford mill through 1981 is about 2,940,000 tons. Hence, the tailings generated under Federal contracts is about 40 percent of the total as of January 1, 1982. Should the mill continue operation through 1990, as is possible from the reported ore reserves of the Midnite Mine, the proportion of tailings attributable to AEC contracts would be only about 26 percent of the total. Continued operation of the Dawn mill to 1990, or even to the year 2000, will depend upon uranium market conditions.

Through 1980, the millfeed at Dawn has averaged 0.23 percent U_3O_8. The overall average through 1990 will be 0.20 percent U_3O_8, assuming the average ore feed for the decade 1980-1990 is 0.15 percent U_3O_8.

Table 1. Dawn Mining Company Tailings Data

	Tailings Areas			
	Areas 1 and 2	Area 3	Area 4	Totals
Type of U_3O_8 Sales	AEC Contracts	Commercial	Commercial	----
Surface Area (acres)	59	46	28	133
Tailings Impounded				
Period (CY)	1957-1965	1969-1981	1981	1957-1981
Quantity (tons)[a]	1,171,000	1,719,000	50,000	2,940,000
Capacity (tons)[a]	1,171,000	1,719,000	1,650,000	4,540,000
Percent AEC-Related Tailings				
As of 1/1/82	100	0	0	40
At Capacity	100	0	0	26

[a] Quantities rounded.

TAILINGS MANAGEMENT HISTORY

Tailings disposal practice has remained unchanged during the life of the operation. The No. 4 CCD thickener underflow is diluted with water to a slurry containing 30 to 50 percent solids. This slurry is then pumped through a 6-inch black PVC pipe about three-quarter mile to the impoundment area. A single discharge is used so that the slimes and water tend to flow away and accumulate near the outermost dike or dam face. However, Dawn officials report that the slime segregation is minimal. No flocculant is added to the tailings to hasten settling but some undoubtedly accompanies the tailings from the CCD circuit. Dawn estimates that the tailings settle to an average density of about 70 percent solids. In the past, tailings pond water has been lost through evaporation and seepage. In the future (about 1983), the clear tailings decant solution in Area 4 will either be returned to the mill for process water or evaporated using a spray system.

Tailings neutralization with lime was used when the mill first started, but was soon abandoned because the neutralized tailings were so difficult to pump. The tailings slurry as discharged at the pond has a pH of 1.8.

Until recently Dawn used a wire-wrapped wood pipe for movement of tailings to the disposal areas. The old wood pipe is being buried in the Area 3 pond. Dawn also has requested State of Washington permission to bury the old ion-exchange columns in the same pond.

Should operations continue past about 1993, another tailings disposal area, perhaps similar to Area 4, will be required. Area 4 is a unique 28-acre membrane-lined subsurface impoundment that is 70 feet deep. It is reported to have cost $2.8 million to construct or about $1.70 per ton of tailings to be impounded.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

Ford, Washington, is a very small community with a widely scattered rural population. Only about 90 people live within a distance of 1 mile and only 465 people within a distance of 6 miles from the millsite. The nearest residence is about 700 yards from the mill. Many of the area residents are members of the Spokane Indian Tribe. Currently, about 136 workers are employed by Dawn's operations, including contractors, and secondary employment generated by the mine/mill operations is another 164, for a total of about 300 jobs. Dawn's Affirmative Action program has a goal of 50 percent Tribal participation.

WATER

The Dawn millsite lies within the drainage basin of Chamokane Creek, the principal surface stream of the Walkers Prairie. The creek flows southwestward, entering the Spokane River about 6 miles below the millsite. Its watershed includes nearly 180 square miles, yielding a mean discharge of 53 cubic feet per second (cfs). Although the creek has continuous flow in the mountainous headwater portion of its basin, the flow is subterranean and surface-intermittent upon entering the gravel-filled floor of Walkers Prairie near Springdale. Several miles downstream, in the vicinity of Ford and the Dawn mill, a series of massive springs emerge, restoring continuous flow to the surface channel. Chamokane Creek does not have a history of serious flooding, and, since the creek meanders through wide flats about 100 feet below the millsite terrace, potential flooding is not a problem.

Because of the high permeabilities of the glacial sands and gravels composing the millsite terrace, there is no other surface stream, and virtually all of the 20 inches of annual precipitation is absorbed into the ground without surface runoff.

The ground water/surface water relationship in Walkers Prairie is complex. The shallow aquifers within the unconsolidated valley-fill materials are quite well understood; however, considerably less is known about the inferred or surmised aquifers associated with the bedrock units. Within the unconsolidated section, significant ground-water flows have been noted.

During 1978, 1979, and 1980, Dawn drilled 21 holes to obtain subsurface geologic information and to establish a ground-water monitoring network. Of these, 12 wells were cased to varying depths as permanent monitoring stations. The standing-water-level elevations in the wells range between 1580 and 1700 feet, or about 60 to 170 feet below the ground surface.

Only recently did Dawn discover the solution seepage emergence zone located one-half mile west of the tailings ponds along the banks of Chamokane Creek. It is apparent that tailings solution acidity (pH=1.8) is swiftly neutralized as it infiltrates the substratum, since all monitor wells and seeps show alkaline pH. This neutralization precipitates and immobilizes most of the heavy metals present in the initial tailings solutions. Similarly, the radionuclides are absorbed onto clay minerals and are not present at levels above normal background in seepage solutions.

Under the terms of Dawn's State of Washington discharge permit, disposal of process waters by seepage is authorized, since in no tested parameter are EPA uranium mill effluent guidelines exceeded. Nevertheless, Dawn considers the seepage undesirable and is now using a membrane-lined tailings pond to halt the seepage. Present seepage comes from the unlined tailings ponds (Areas 1, 2, and 3), and Dawn is concerned that the state may require purging. To do so would require drilling of wells or excavating deep trenches to intercept solutions which then would require evaporation or chemical treatment before release. Evaporation might be feasible since the net annual evaporation in the Ford area is about 18 inches. However, purging the seepage would be expensive and might require several years depending upon the rate of movement of solutions and the decontamination criteria imposed.

AIR

Records from Spokane indicate the prevailing winds blow from the southwest and south-southwest. However, during the winter months, the air flow is commonly reversed, with winds out of the northeast. The average annual wind speed is 8.5 miles per hour.

The remoteness of the Dawn site and the absence of many nearby residents tend to minimize the potential health impacts that might possibly result from both the release of radon and inhalation of suspended particulates.

SURFACE CONTAMINATION

The blowing of tailings at Dawn was a problem in the past, especially when the tailings surfaces became dry. The interim stabilization or the coverings on Areas 1, 2, and 3, and the subsurface storage in Area 4, should obviate any future wind transport of tailings. Some windblown tailings have been cleaned up by Dawn, and cleanup is expected to continue in the lightly contaminated off-site areas. Cleanup of all on-site surface contamination, except under tailings impoundments, will await mill decommissioning and final tailings stabilization.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

As previously mentioned, Dawn is performing interim stabilization of tailings Areas 1, 2, and 3 by covering the top surface with wood chips or dirt to prevent wind transport of tailings. Vegetation is being established on the top and side slopes of the dikes.

Current State of Washington regulations require sufficient natural cover to be placed over tailings at the end of milling operations to reduce the surface exhalation of radon to less than $2 pCi/m^2$-sec above natural background levels. The minimum allowable depth of cover is 3 meters, enough to reduce gamma radiation to background levels and radon emissions to about twice background. When Dawn filed its original license renewal application in July 1979, it committed itself to 2 feet of clay and sufficient earth to bring the cover to 3 meters in depth. In light of the lack of locally available clay and its high cost to import, Dawn subsequently proposed instead to use 18 feet of only native soils.

Currently the Battelle Pacific Northwest Laboratories is conducting field studies on radon emanation and attenuation by various cover materials specific to the Dawn site. When final results from this study are available, a more accurate calculation can be made of the depth of cover required. Meanwhile, the state is proceeding to implement the 3-meter standard.

Dawn officials state that there was sufficient material excavated from Area 4 to provide 18 feet of cover for 95 percent of Area 3. Should operations continue beyond the life of Area 4, another subsurface disposal facility (Area 5) could possibly provide all the cover needed for Area 4. Presently, Dawn management does not know where one might obtain sufficient cover for tailings Areas 1 and 2.

Dawn has no plans to move tailings from Areas 1, 2, or 3 and logically those tailings should be stabilized in place. Purging the seepage from those areas, if required by the state, could be an expensive project.

The current situation on long-term maintenance and surety arrangements is as follows:

(1) Dawn pays the state 5 cents per pound of U_3O_8 sold until $1 million has been accumulated. This money is to be used by the state for long-term care and maintenance of the tailings. (Western Nuclear at Wellpinit also is required to contribute 5 cents per pound.) Under provisions of the Washington State Mill Licensing and Perpetual Care Act of 1979, uranium mill tailings disposal sites will be deeded to the state at the time of permanent cessation of milling for purposes of perpetual care.

(2) For Area 4, Dawn posted a $1 million letter of credit with the state for reclamation and disaster protection.

(3) For renewal of its source materials license, Dawn will have to post a new bond for decommissioning, decontamination, and tailings stabilization, the amount of which has yet to be set by the state.

(4) For every ton milled, Dawn puts an undisclosed sum of money into a fund that is dedicated by Dawn exclusively to decommissioning and reclamation.

The state, in approving Dawn's tailings expansion project, Area 4 below-grade disposal, required Dawn as a condition of its license to prepare a revised tailings reclamation plan incorporating a final cover of rock or stones on side slopes "of a size sufficiently large so as not to be susceptible to dislocation from human or animal activity at the site." The plan is to include both the subsurface area as well as the above-grade tailings disposal areas.

Dawn has made no recent estimates of decommissioning and tailings stabilization costs because regulations are so uncertain. The interim stabilization costs (coverings for Area 3 and hydromulching of dikes) were termed as "relatively inexpensive" because much of the work was done during slack time in construction activities while earth-moving equipment was on-site for construction of Area 4.

A 1980 cost estimate of mill decommissioning and tailings stabilization was $4.9 million. Because of the uncertainty of future reclamation requirements, the NRC has recommended that the option for amendment of reclamation requirements remain available to Dawn. In the meantime, however, Dawn is required to remain bonded for an amount sufficient to include reclamation of Area 4.

Dawn had no cost estimates for purging the seepage or retrieving windblown tailings. There would be no cost at Ford for off-site remedial action since no tailings were removed from the site.

DISCUSSION OF FEASIBLE COST-SHARING PLANS

Dawn officials stated that Dawn would prefer an arrangement whereby only tailings resulting from commercial sales would be stabilized by Dawn. Dawn proposed that the Federal Government take care of stabilizing the tailings in Areas 1 and 2 that resulted from uranium sales to the AEC. Such an arrangement, in the opinion of Dawn officials, would be preferable to cost-sharing in proportion to the quantities of tailings. Dawn reportedly has sufficient earth cover for the commercial tailings but apparently not for the tailings in Areas 1 and 2.

By letter dated February 9, 1982, the President of Dawn Mining Company succinctly explained Dawn's position regarding cost-sharing. Besides advocating that the Government take full responsibility for stabilizing those tailings attributable to AEC contracts and impounded separately at Dawn from commercial tailings, he said Dawn would consider a U_3O_8-production-related basis to be appropriate for sharing other costs, such as decommissioning, perpetual care, etc.

REFERENCES

"Commingled Tailings at Dawn," Dawn Mining Company, Memorandum Report to the American Mining Congress, 1981.

"Dawn: A First-Generation Plant with Column Ion-Exchange," Engineering and Mining Journal, November 1978, pp. 118-121.

"Dawn Mining's Tailings Expansion Project: A Case Study in the Use of HDPE Lining," David Small, Jack Thompson, and Ronald Versaw, presented at a symposium on Uranium Mill Tailings Management, Fort Collins, Colorado, October 26-27, 1981.

"Final Environmental Impact Statement for the Proposed Dawn Mining Company Mill Tailings Expansion Project," State of Washington Department of Social and Health Services, 1981.

"Tailings Disposal Facility Expansion Project, Environmental Impact Statement," Dawn Mining Company, 1979.

FIGURES

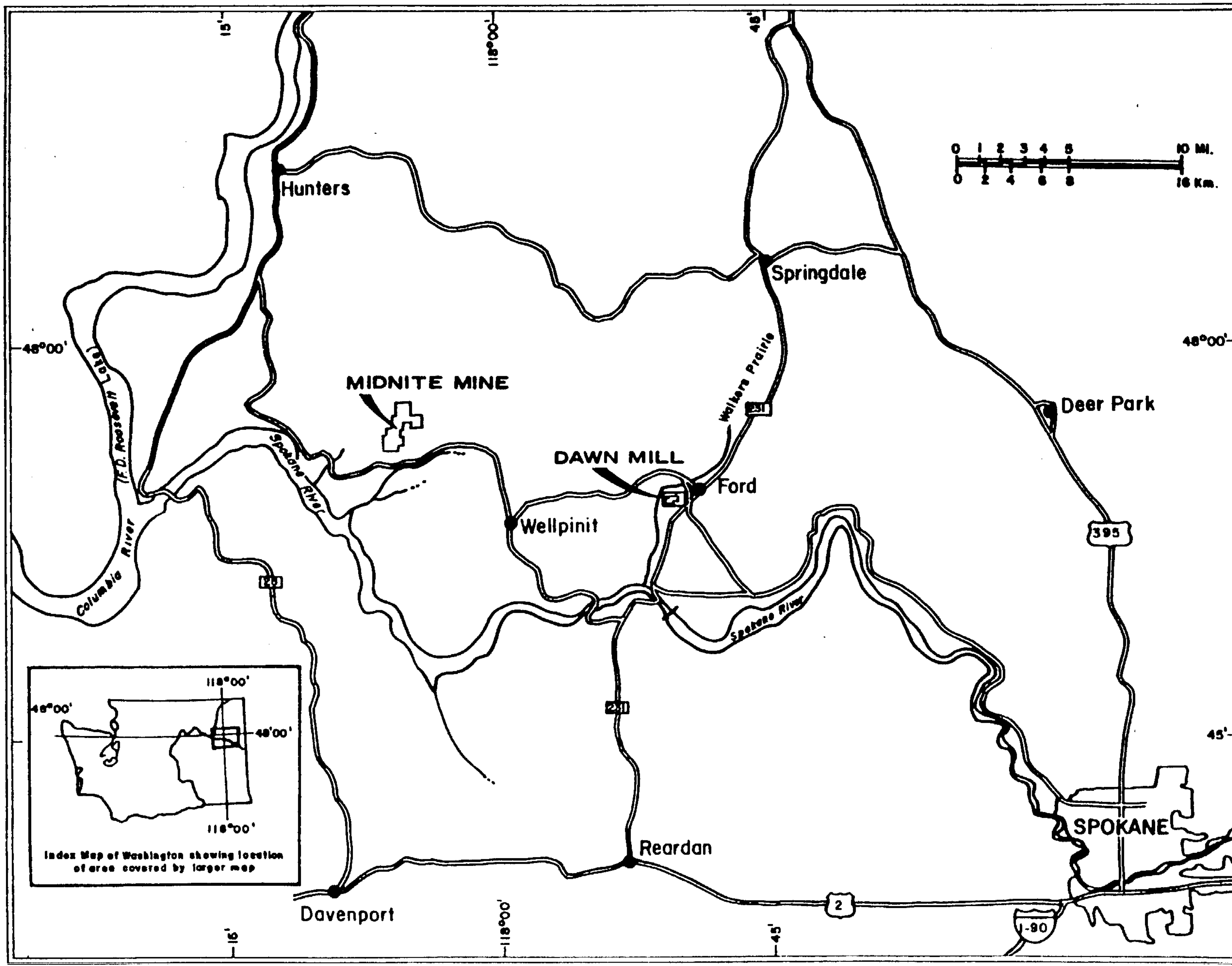

Figure 1. Location Map: Dawn Mining Company, Ford, Washington

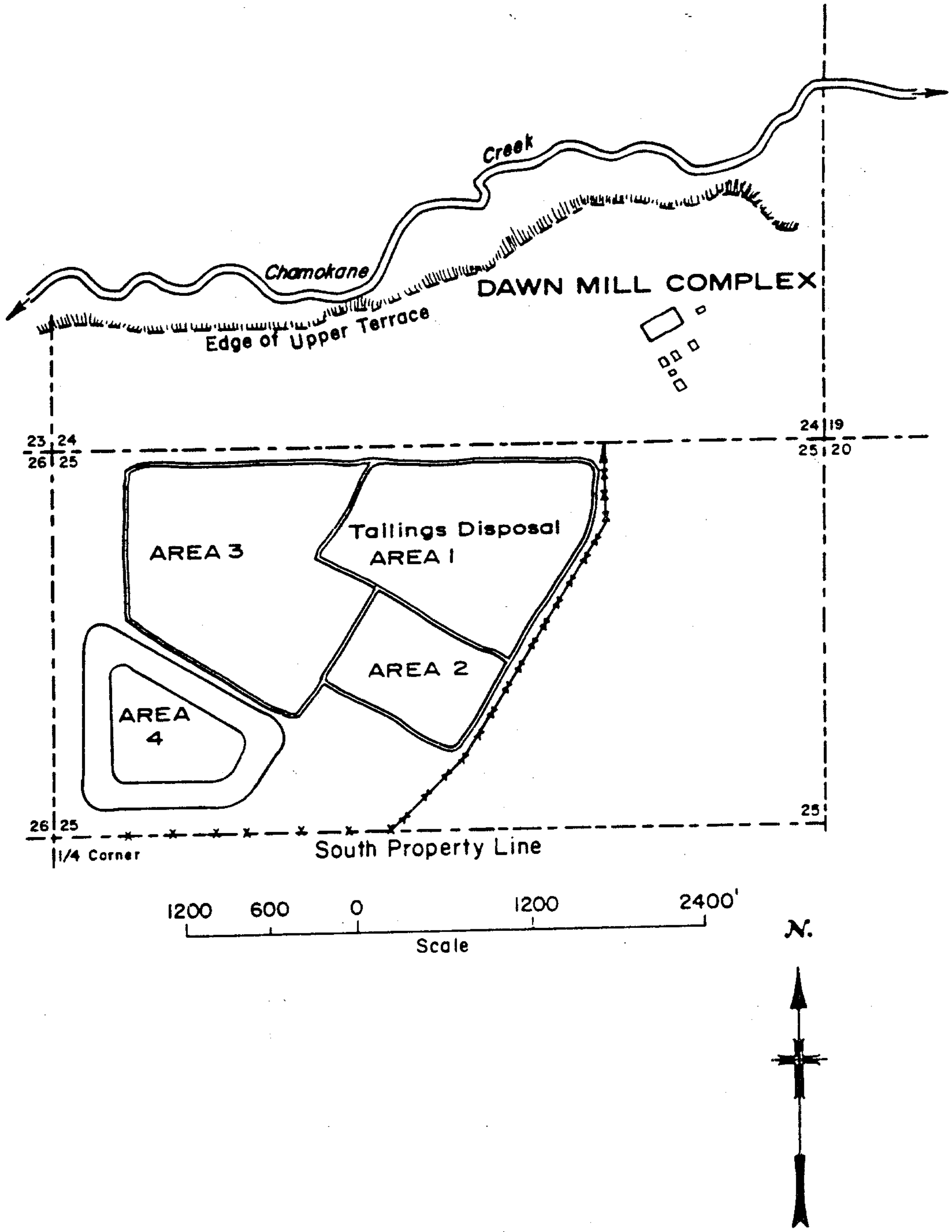

Figure 2. Plan Map of Mill and Tailings Pond Area: Dawn Mining Company, Ford, Washington

SITE REPORT: FEDERAL-AMERICAN PARTNERS
Gas Hills District, Wyoming

INTRODUCTION

Federal-American Partners (FAP) operated a uranium ore processing plant or mill in the Gas Hills District, Wyoming, during the period 1959-1970 to produce uranium for sale to the Atomic Energy Commission (AEC) for use in defense programs. During the latter part of this period, some uranium was produced for sale in the commercial market. Since mid-1969, all uranium production has been for that market. Tailings from production under AEC contracts have been commingled to varying degrees with tailings from production for commercial sales.

In April 1973, the Tennessee Valley Authority (TVA) leased the partnership properties and has a contractual first right to use the mill. Milling operation was suspended on October 30, 1981, and the mill is now in a "standby" mode.

BACKGROUND AND HISTORY

OWNERSHIP

The mill is located on 20 acres of patented land. Tailings occupy lands possessed as unpatented mining claims acquired under the Mining Law of 1872. Surface rights have been retained by the U.S. Government although FAP has proposed to purchase them through the Bureau of Land Management.

Federal-American Partners is made up of Federal Resources Corporation (60 percent) and American Nuclear Corporation (40 percent). Federal Resources is the managing partner. However, the Vice President of Operations for American Nuclear is presently Acting Project Manager. TVA has a lease until 1990 on the partnership properties or so long thereafter as the properties are in production or diligent efforts are being made to get into production, and TVA also has a contractual first right to use of the mill. TVA controls the production schedule.

Federal-American Partners announced in February 1982 that it has agreed in principle to sell its interest in uranium properties in the Gas Hills area of Wyoming to TVA. TVA will pay $4 million for the properties to FAP, plus a royalty on future concentrate production.

The licensing authority for the FAP mill is the Nuclear Regulatory Commission (NRC) since Wyoming is not an Agreement State. The mill was first licensed by the AEC in 1959. The last license issued by the AEC expired January 31, 1976. FAP applied for renewal of its source materials license but the NRC has yet to renew the license. The mill has been operating under a timely renewal application. The NRC has in preparation a draft environmental statement concerning the license renewal which FAP believes will be released soon for comment. The Wyoming Department of Environmental Quality (DEQ) has expressed a preference to have all past and future tailings impounded below surface.

PRODUCTION HISTORY

The initial AEC contract was signed with Federal-Radorock-Gas Hills Partners on April 10, 1959. The mill was constructed and the first uranium concentrate was delivered to the AEC on February 1, 1960. The partnership entered into a stretch-out contract with the AEC on January 28, 1965. Federal deferred approximately 1.4 million pounds U_3O_8 from the 1962-1966 period until 1967-1968. With various mergers and acquisitions, the partnership was later changed to Federal-American Partners.

The concentrate delivered under the AEC contract was as follows:

Contract No.	Period (CY)	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-760	1959-1969[a]	6,469,895	7.92

[a]Contract period was through December 31, 1970, but the last lot was delivered to the AEC in June 1969.

The mill began operation in October 1959 with an initial rated capacity of 520 tons of ore per day. Subsequent expansions and process modifications increased the capacity to 950 tons per day in 1964. As noted earlier, the mill was shut down on October 30, 1981.

During the period 1959-1970, FAP processed 2,676,313 tons of ore averaging 0.19 percent U_3O_8. The recovery of U_3O_8 from the ore averaged 92 percent, indicating a residual U_3O_8 content in the tailings of only 0.015 percent. Part of the above ore (an estimated 155,000 tons) was processed on a toll basis for Susquehanna Western, Inc., during the period 1963-1966.

During the period of the AEC contract, only uranium was recovered, no byproducts. In later operations, small quantities of molybdenum were removed primarily for process control and to meet product specifications.

The future of the operation is not clear. TVA anticipates U_3O_8 needs beginning in 1986 which may cause operations to resume. However, TVA representatives stated that if U_3O_8 can be purchased on the market below the costs of producing it at FAP, the mill will not be reactivated.

PROCESS DESCRIPTION AND MAJOR CHANGES

The mill began operating in October 1959 with a nominal capacity of 580 tons per day, utilizing an acid leach followed by removal of the dissolved uranium from a slime pulp in a continuous countercurrent resin-in-pulp (RIP) circuit. In the original process, an acidified ammonium nitrate solution was used for elution in the RIP circuit, and the eluate was neutralized to precipitate the uranium.

In 1964, the Eluex process was added and the mill was expanded to a nominal capacity of 950 tons per day. In the Eluex process, sulfuric acid is used for elution of the resin. The uranium is extracted from the eluate in a solvent extraction circuit and most of the acid is returned to the resin elution circuit. The uranium is stripped from the organic solvent with ammonium sulfate and is precipitated with ammonia to produce a high-grade (95 to 96 percent U_3O_8) concentrate product.

The mill processes ore from both surface and underground mines operated by FAP in the Gas Hills area. Uranium recovery at the FAP mill has always been good, even while treating relatively low grade ores.

SITE DETAIL

LOCATION

The FAP mill and tailings impoundments are in a hilly area of Wyoming, east of Riverton (about 50 miles), as shown in Figure 1. The site is located in Sections 28 and 33, T33N, R90W, 6th P.M., Gas Hills Mining District, Fremont County, Wyoming.

TOPOGRAPHY

The topography is classified as rolling hills at an average elevation of 6500 feet. Relief is on the order of a few hundred feet. Various prairie grasses and sagebrush are the predominant vegetation. The FAP site is in the Willow Springs Draw which is formed by an intermittent tributary to the Wind River.

CURRENT CONDITION OF TAILINGS

All available tailings storage capacity was full, as defined under conditions of the source materials license, as amended, when mill operations were suspended on October 30, 1981. Tailings Pond No. 1 (38.5 acres) and Tailings Pond No. 2 (78.5 acres), as shown in Figure 2, have been the only areas used for tailings impoundments.

An aerial view of the tailings, as of August 1979, is shown in Figure 3. Efforts are made to keep the tailings moist to prevent wind erosion and dusting. Since plant shutdown, water sprinklers have been placed on the tailings to keep surfaces wet. A chemical stabilizer, Coherex, has been used in the past to cement the sands on the slopes of the piles. FAP is investigating other stabilizers which may maintain the integrity of the surfaces longer.

Last year the north faces of the dikes on both ponds were hydroseeded with a wheat grass and wood fibers. This project was very successful on the dikes of Pond No. 1, but not quite as good on parts of the dikes of Pond No. 2 where acidic conditions exist. However, even without vegetation, the wood fibers alone have helped keep wind and water erosion down.

QUANTITIES

Table 1 presents the quantity of tailings as of December 31, 1970 (end of the AEC contract period), and as of December 31, 1981. The percentage shown for AEC-related tailings may not be final, pending possible resumption of operations.

Table 1. FAP Tailings

	12/31/70	12/31/81
Quantities (tons)		
AEC Contract	2,095,524	2,095,524
Commercial Sales	580,789	3,785,764
Totals	2,676,313	5,881,288
AEC Percent	78.3	35.6
Acres Covered	85	117
Average Depth (feet)	40	50
Range (feet)	(20-45)	(25-65)

TAILINGS MANAGEMENT HISTORY

Since mill start-up, the tailings sands and slimes, separated during processing, have been rejoined in an agitated tank, sampled, and pumped to above-ground unlined impoundments. Since June 1980, between 100 and 150 gpm of the tailings solution or decant has been returned to the mill. Tailings Pond No. 1 is filled only with tailings resulting from production of uranium for sale to the AEC, while Pond No. 2 contains commingled tailings, a mixture of tailings from production both for the AEC and commercial sales. The exact distribution of the total tonnage of tailings between the two ponds is not known, but FAP estimates that 30 percent of the tailings in Pond No. 2 is attributable to U_3O_8 production for the AEC. After construction of Pond No. 2 in April 1960, overflow from it was decanted into Pond No. 1, and this decant contained some unsettled slimes.

Impoundment in Pond No. 1 was accomplished by constructing a 45-foot earthen dam at the north end of a small drainage basin. Pond No. 2 was created by constructing an earthen dike around a gently sloping area. At its highest point (north end), it is about 75 feet high, although it grades into natural ground in the southwest corner. The present elevation includes a 21-foot-high dam addition that was completed in December 1979. The NRC has limited the liquid level in the pond to an elevation of 6495 feet. The NRC requires that the top 14 feet of dam capacity be left as freeboard to ensure against liquefaction of the portion of the dike which is built with sand tailings in case of a seismic event.

As noted earlier, FAP's tailings areas have reached their allowable capacities. FAP has been evaluating the feasibility of disposing of mill tailings below grade in a nearby inactive open-pit mine. The total below-grade tailings area would be about 60 acres and would provide 20 years of capacity or about 11 million tons of tailings. Neither the NRC nor Wyoming's DEQ have as yet approved the plan, although FAP believes that they have satisfied all of the NRC's concerns. FAP had also considered a plan which would extend Pond No. 2 to the north and west.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The immediate area is sparsely populated. Only 86 people reside permanently within 5 miles of the FAP site. The city of Riverton (population 9500) is about 40 air miles to the west, Jeffrey City (population 350) is 25 miles south, Shoshoni (population 880) is 35 miles to the northwest, and Casper (population 50,000) is 65 miles east of the site. A camp for mill and mine workers consisting of about 20 structures and mobile homes was at the site, about 1/2 mile west of the mill, but is now being decommissioned.

AIR

At the FAP site, the prevailing wind direction is from the south and southwest, and wind speeds are often high; however, local topography, buildings, dikes, etc., influence the degree of air turbulence in the local area of the tailings. Tailings Pond No. 1 is wet from the introduction of overflow from Pond No. 2, thereby reducing windborne activity. Five stations to monitor windborne radioactive elements have been placed around the site and show some migration, all within standards set forth in 40CFR190. Because of the close proximity of other mill operations, numerous open-pit mines (active and inactive), and ore spillage, the true influence of the site may be hard to distinguish from other sources.

WATER

There are no streams flowing out of the Gas Hills Mining District. The creeks flow only after occasional storms. Precipitation is on the order of 10 inches per year.

The primary or major ground-water aquifer in the area is the lower Wind River Formation at a depth of 120 to 145 feet, with some seasonal fluctuation of ± 5 feet. This aquifer is the source of water for the operation.

FAP has 37 monitoring wells to detect migration of solutions. FAP has detected no contamination of the major aquifer. Although the tailings ponds rest unlined on gravel strata, there apparently is insignificant seepage to affect the quality of ground water. It is evident that underlying tight shales, 20 to 30 feet thick, protect the water table.

SURFACE CONTAMINATION

The extent of surface contamination at the FAP site would be difficult to assess until at the time of decommissioning. As noted earlier, the air monitoring program indicates some migration of tailings in prevailing wind directions but the exact extent is difficult to determine because of the close proximity of open-pit mines, ore haulage roads, other mills, etc. Surface cleanup, however, at the time of decommissioning should be relatively easy because of a soil cover and somewhat flat terrain.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

FAP has submitted two plans to the NRC and DEQ for stabilizing the present tailings. In one plan, the tailings in Ponds No. 1 and 2 would be covered with 8 to 13 feet of pit spoils which was estimated to cost $1 million (1978 dollars), the amount for which FAP is currently bonded. The alternative plan for subsurface disposal of the tailings in an inactive open pit was estimated to cost between $25 and $30 million, including preparing the pit plus moving the tailings. No mill decommissioning costs are included in these cost estimates.

FAP officials noted that, since September 1977, the company has been working on a plan for tailings management. After more than three years of providing state- and Federal-requested alternatives and revisions, and construction of temporary facilities, at a cost of over $4.2 million, FAP still does not have an approved operating tailings plan.

DISCUSSION OF FEASIBLE COST-SHARING PLANS

Some of the cost-sharing approaches that might be considered for this site are as follows:

(1) Proportionality of AEC-Related Tailings to the Total as of January 1, 1982
This approach is based on the premise that no additional tailings will be added to Ponds No. 1 and 2 and that the Federal Government share for stabilizing the tailings on a tonnage basis would be 35.6 percent.

(2) Based on Acreage
As of January 1, 1982, the tailings attributable to the AEC contract are located on 117 acres and comprise 35.6 percent of the total tonnage. Hence, the Federal Government would be responsible for the stabilization of about 42 acres, which could be stabilized whenever FAP chose to do so.

(3) Federal Share Based on Total Cost of Pond No. 1 and Proportionate Share of Pond No. 2
All the tailings in Pond No. 1 derived from production for the AEC contract, while Pond No. 2 contains commingled tailings. It is estimated that 30 percent of the tailings in Pond No. 2 is attributable to AEC contracts. The number of acres for which the Government would be responsible would be 38.5 (Pond No. 1) plus 30 percent of 78.5 (Pond No. 2), for a total of 62.

Early discussions with FAP officials centered only on cost-sharing approach (1), described above, and no consensus developed around this concept. Instead, FAP officials addressed a different philosophy; i.e., that the Government or taxpayers should bear the expense of any new Government regulations which upset and changed the base from which business judgments were made at the time of production. It was suggested that a study be undertaken that would determine the timing of the various state and Federal regulations which have emerged, and thereafter a judgment be made as to the impact such regulations have had on costs and prior business decisions.

FAP favors approach (3), described above, as being the most equitable. If and when operations resume, no more tailings will be added to Ponds No. 1 and 2, but they would be used for solution evaporation, and reclamation would be accomplished at the end of operations.

REFERENCES

Report to American Mining Congress, submitted by Federal Resources Corporation, April 15, 1981.

FIGURES

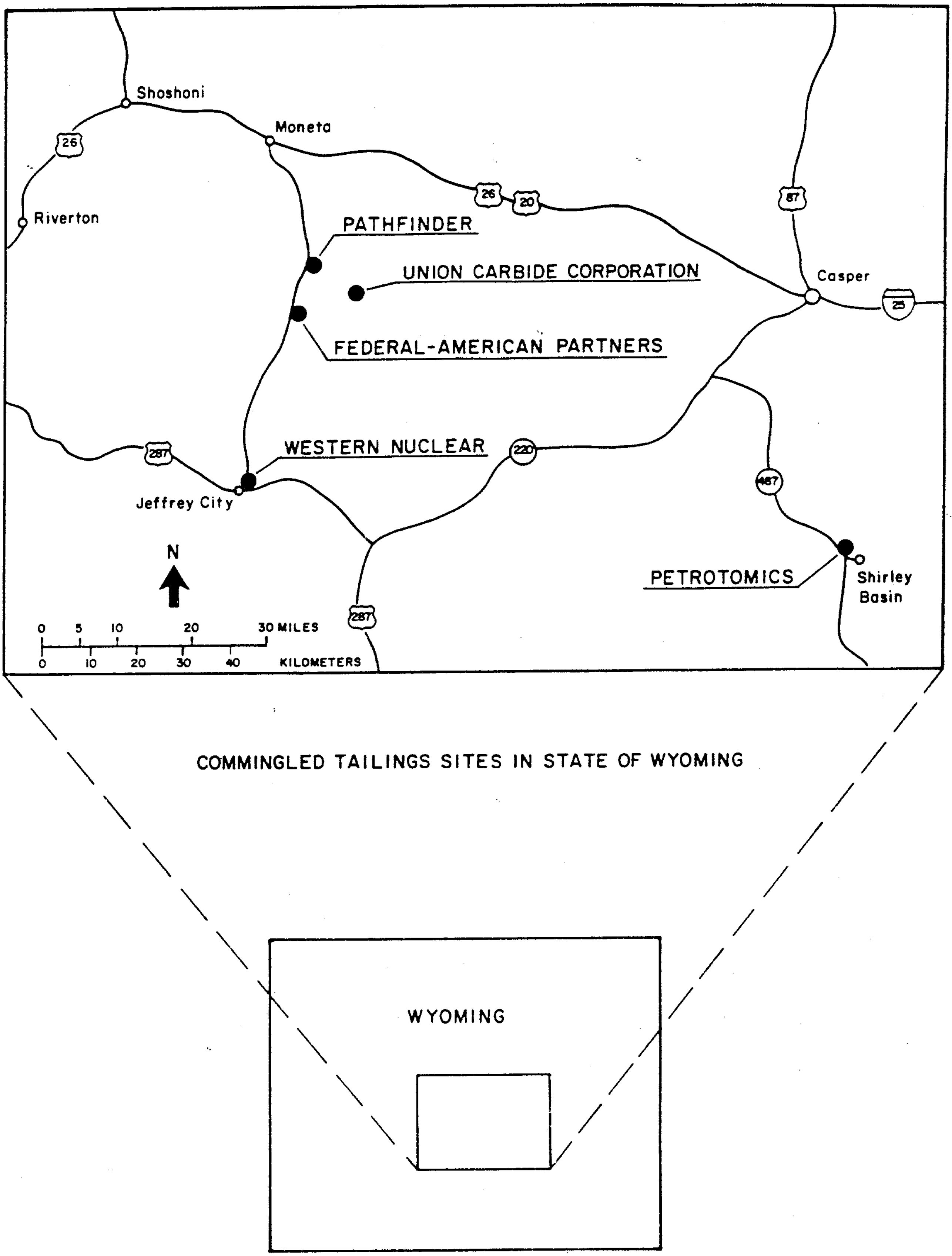

Figure 1. Location Map: Federal-American Partners, Gas Hills, Wyoming

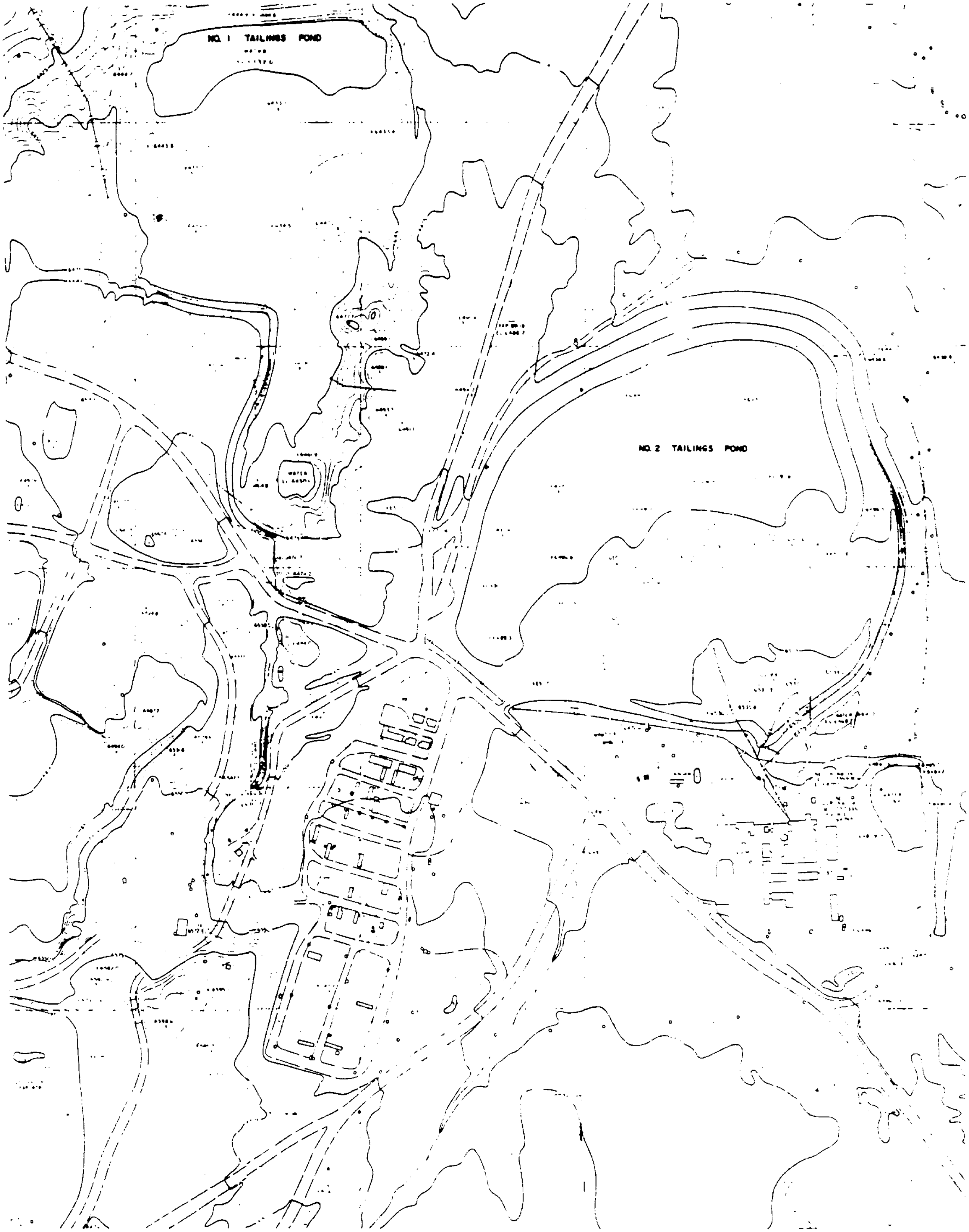

Figure 2. Topographic Map: Federal-American Partners Millsite and Tailings Ponds

SITE REPORT: PATHFINDER MINES CORPORATION
Gas Hills District, Wyoming

INTRODUCTION

The mill operated by Pathfinder Mines Corporation (Pathfinder) has been in operation since February 1958. The mill was built to exploit uranium ore bodies discovered by Neil McNiece in the early 1950s in the Gas Hills District of Wyoming. The licensing authority for the Pathfinder mill is the Nuclear Regulatory Commission (NRC) since Wyoming is not an Agreement State. Pathfinder is operating under Source Material License No. SUA-672 which will expire in 1983.

BACKGROUND AND HISTORY

OWNERSHIP

Pathfinder owns and operates a uranium processing plant, auxiliary installations, and impounded uranium tailings in the Gas Hills District in Fremont County, Wyoming. All of the tailings produced under two AEC contracts are situated on patented and unpatented millsite claims held by Pathfinder. Most of the tailings solution ponds are on patented millsite claims, but portions are on Wyoming state land, under lease to Pathfinder, and on unpatented millsite claims controlled by Pathfinder.

The Lucky Mc Uranium Corporation was formed in the early 1950s to mine and process the McNiece ore bodies, and Utah Construction and Mining Company, which later became Utah International, Inc., acquired Lucky Mc Uranium Corporation a few years later. When Utah International merged into General Electric Company, the uranium mining and milling operations were consolidated under a separate corporation renamed Lucky Mc Uranium Corporation. The corporate name was subsequently changed to Pathfinder Mines Corporation with no other organizational or ownership changes at that time.

PRODUCTION HISTORY

The Atomic Energy Commission (AEC) and Utah Construction and Mining Company entered into Contract No. AT(05-1)-710, effective November 14, 1956. This contract was superseded by Contract No. AT(05-1)-769, effective June 30, 1959. The uranium concentrate sold to AEC is summarized as follows (DOE figures):

Contract	Period	U_3O_8 (lbs.)	Price ($/lb.)
AT(05-1)-710	3/58-7/59	2,183,220	8.99
AT(05-1)-769	7/59-12/70	14,564,982[a]	7.59
Totals		16,748,202[a]	7.76

[a]Includes 97,814 pounds of U_3O_8 processed by Petrotomics Company for Utah Construction and Mining Company and sold to AEC under Contract No. AT(05-1)-769.

Utah Construction and Mining Company constructed a mill with a nominal capacity of 750 tons per day in 1957. The mill began producing uranium concentrate for sale to the AEC in March 1958. In 1967, the mill capacity was increased to 1200 tons per day, and subsequent modification and expansion have increased the capacity to 2800 tons per day. Currently, it is operating at about 1650 tons per day.

During the period March 1958 through December 1970, Pathfinder processed 3,489,000 tons of ore averaging 0.31 percent U_3O_8. The average mill recovery was approximately 95 percent.

Approximately 260,000 tons of low-grade or protore were heap leached on the millsite from June 1959 to October 1962. All of this product was sold to the AEC. As of December 31, 1968, 168,000 tons of heap-leach "tailings" remained on-site. Some 92,000 tons of the leached material were fed to the mill. The mill tailings resulting from the portion fed to the mill are contained in Pond No. 2A. This tonnage is included in the tailings figures shown for Pond No. 2A in Table 2.

Sales of U_3O_8 on the commercial market began in 1967 and have continued to date. During the period March 1958 through December 1981, the mill produced 41,414,136 pounds of U_3O_8 in concentrate. Under current sales agreements, Pathfinder will continue to operate the plant through 1985 at the current rate of 1650 tons per day. Under favorable market conditions, resources are adequate to continue milling operations through 1996 at the rated capacity of 2800 tons per day.

PROCESS DESCRIPTION

The process initially used at the Lucky Mc mill included (1) ore handling, (2) crushing, drying, and sampling, (3) grinding and classifying, (4) two-stage acid leaching, (5) countercurrent decantation, (6) solution clarification, (7) ion exchange, (8) precipitation, (9) filtering and drying, (10) packaging and shipping, and (11) tailings disposal. It was the first mill in the United States to utilize the moving-bed ion-exchange technique originally developed in South Africa. In 1967, the mill was converted to the Eluex process by adding a solvent extraction circuit to further purify the ion-exchange eluate prior to precipitation, and the capacity of the mill was increased to about 1200 tons of ore per day.

In 1978, a semiautogenous grinding circuit replaced the original crushing and grinding operations, and, in 1979, a resin-in-pulp circuit was added to operate in parallel with the column ion-exchange circuit. These changes expanded the mill capacity to 2800 tons per day. Only uranium has been recovered during the operation of the mill.

In-Situ Leaching

Between 1963 and mid-1970, Utah Construction and Mining Company produced 1,490,433 pounds of U_3O_8 in uranium solutions by in-situ leaching at its mining property in Shirley Basin, Wyoming. The uranium was extracted in an ion-exchange plant near the mine site, where the uranium was precipitated from the eluates. The thickened concentrate was then shipped to the Lucky Mc mill where it was added into the precipitation circuit. During the period from March 1963 through September 1964, the company produced 185,559 pounds of U_3O_8 from mine waters in the Gas Hills Mining District and fed them to the precipitation circuit in the Gas Hills mill.

Heap Leaching

Quantities were discussed in detail under the Production History section of this report. During the summer seasons between June 1959 and October 1962, Utah Construction and Mining Company heap leached low-grade material assaying 0.05 to 0.07 percent U_3O_8. Barren solutions from ion exchange were used as the leaching agent. The leached uranium was sent to the mill ion-exchange circuit for further processing.

SITE DETAIL

LOCATION

The Lucky Mc mill and tailings disposal area are located on patented and unpatented millsite claims acquired under the Mining Law of 1872. Portions of tailings Pond 2A and a portion of some solution ponds are on land leased from the State of Wyoming. These millsite claims and state land are on parts of Sections 9, 10, 15, 16, 21, and 22 of Township 33 North, Range 90 west, 6th P.M., Gas Hills District, Fremont County, Wyoming.

Figure 1 shows the position of the mill with respect to the nearest towns and other active uranium processing plants. The nearest town is Jeffrey City, about 30 miles south of the plant site.

TOPOGRAPHY

The Gas Hills Mining District is in the southeastern portion of the Wind River Basin, which is both a topographic and a structural basin. Altitudes in the basin range from 4400 feet at the north end of the Wind River Canyon to more than 13,000 feet at the crest of the Wind River Mountains. Upturned rocks form distinct cuestas and hogbacks (ridges) along mountain fronts; in the more central parts of the basin, nearly horizontal rocks form broad valleys and gravel-capped mesas and buttes. The mesas, buttes, and cuestas form drainage divides between the smaller ephemeral streams. North and west of the Lucky Mc mill, toward the center of the Wind River Basin, the land ranges from gently rolling plains to deeply dissected stream valleys leading to the Wind River Valley.

The topography in the vicinity of the Lucky Mc mill features gently rolling hills and hogback ridges providing relief of a few hundred feet. The mill is located at an elevation of 6460 feet at the head of Reid Draw, near the center of Section 22.

The dominant topographic features in the vicinity of the mill are the hogback ridges of the northwesterly plunging Gas Hills (Dutton Basin) Anticline and the steep northeasterly trending Beaver Divide escarpment in the southern margin of the basin and Sarcophagus Butte adjacent to the mill. The Gas Hills hogbacks reach elevations of 6700 feet east of the mill, and Sarcophagus Butte, northwest of the mill, reaches to over 6500 feet. The steep north face of Beaver Divide rises 300 to 800 feet above the basin floor. The rim of the Beaver Divide escarpment is essentially the drainage divide between the northward-flowing tributaries of the Sweetwater River, having low gradients.

CURRENT CONDITION OF TAILINGS

The waste retention system consists of five unlined ponds, identified as Nos. 1, 2, 2A, 3, and 4. They are located at the head of Reid Draw Basin and occupy a total of 477 acres (see Figures 2 and 3 for the layout of these ponds).

Ponds No. 1 and No. 2, 44 acres and 53 acres, respectively (as of December 31, 1981), jointly hold all the commingled solid tailings (8,213,000 tons). Pond No. 2 is filled to capacity. Distribution of the tonnage contained in each pond is not known; however, Pathfinder estimates that approximately 75 percent of the tailings attributable to operations in support of the AEC program is in Pond No. 1.

Pond No. 2A, 151 acres, is a newly constructed disposal area which began to receive tailings in March 1980. As of December 31, 1981, Pathfinder estimated that it contained 1,300,000 tons (see Table 2).

Tailings solutions are retained in Ponds Nos. 3 and 4. No solid tailings are impounded in these two ponds. The combined available area of the solution ponds totals 224 acres.

Impoundment is accomplished through earthern dams or dikes utilizing the natural containment provided by Reid Draw. These dams have a descending crest elevation as shown in Table 1 (Pathfinder data).

Table 1. Tailings Dams: Maximum Elevation and Height at Highest Point

Pond No.	Crest Elevation	Height (feet)
1	6400	79
2	6372	82
2A	6360	104
3	6270	54
4	6256	98

Only Pond No. 2 is totally inactive. Currently, tailings are going to Pond No. 2A. Ponds Nos. 3 and 4 contain solutions only, no tails. Accordingly, the only pond that has an exposed, dry surface is Pond No. 2. Fortunately, when the surface of the tailings becomes dry, a gypsum cement forms and minimizes the problem of windblown particulate matter.

QUANTITIES

Table 2 presents the quantity of tailings as of December 31, 1970 (end of the contract period), and as of December 31, 1981.

Table 2. Pathfinder Mines Tailings

	Ponds 1 and 2 12-31-70	Ponds 1 and 2 12-31-81	Pond 2A
Quantities (tons)			
AEC Contracts	2,842,000[a]	2,842,000[a]	0
Commercial Sales	816,000	5,372,000[c]	1,300,000[c]
Totals	3,658,000[a]	8,213,000[a]	1,300,000[c]
AEC Percent of Tons	81.5	34.6	0
Acres Covered	97[b]	97[b]	151[c]
Average Depth (feet)	32[b]	32[b]	

[a]Includes 168,000 tons of heap-leach residues.

[b]From Pathfinder report to American Mining Congress.

[c]Pathfinder-supplied figure.

TAILINGS MANAGEMENT HISTORY

Underflow from the final thickener in the countercurrent decantation circuit is pumped to a tailings disposal pond along with a portion of the barren solution discharged from the ion-exchange circuit. Part of the solution decanted from the pond is returned as wash solution to the final countercurrent decantation circuit thickener. Surplus solution, along with the remainder of the barren solution from ion exchange, is diverted to evaporation ponds.

Solid tailings were impounded in Ponds 1 and 2 from March 1958 until March 1980. Excess solutions were diverted to Ponds 3, 3A, and 4. In 1979-1980, a dam was constructed to contain solid tailings in a new pond designated 2A. This dam was constructed to contain all the solid tailings that are expected to be generated during the remaining life of the mill.

The dam impounding solutions in Pond 4 was constructed in 1980-1981 inundating Pond 3A. It meets the rigid standards necessary to ensure that it will contain all the tailings and solutions that might be released in the event that seismic impact resulted in a breach of the upstream dams.

ENVIRONMENTAL CONDITIONS

DEMOGRAPHY

The region is rural in character and sparsely populated. Figure 1 shows the location of the Gas Hills Mining District and the mills. The nearest communities with significant population are Casper, 50 miles to the east (population 50,000); Riverton, 50 miles to the west (population 9600); Shoshoni, 40 miles to the northwest (population 1200); and Jeffrey City, 30 miles to the south (population less than 2500). Less than 100 people live within 5 miles of the mill. A few ranches are located within 20 miles of the mill.

As at all uranium mills, the main environmental considerations are potential health effects due to gamma radiation on-site; escape of radon from tailings; contamination of surrounding area with windblown tailings; and possible contamination of ground waters by seepage from tailings piles.

WATER

The Gas Hills uranium ore deposits are in sandstones of the upper Wind River Formation of Tertiary age. Most of the production has been from large open-pit mines. Three formations crop out in the vicinity of the Pathfinder tailings disposal area and underlie the mill area. These are the Cody shale (Cretaceous), lower Wind River Formation (Tertiary), and Reid Draw alluvium (Quaternary).

The tailings system is located at the head of the Reid Draw drainage. The lower No. 4 dam essentially forms a closed basin (see Figure 2, which is taken from the NRC Environmental Statement, NUREG-0357, dated November 1977). The ground-water system in the Reid Draw alluvium is referred to as the Reid alluvial aquifer. Estimated rates of ground-water movement in this aquifer are low, less than 10 feet per year. The lower fine-grained Wind River Formation is the bedrock in some of the tailings area. The saturated portion of the lower Wind River Formation and overlying Frazer Draw Alluvium are classified as the Wind River aquifer, which has a rate of ground-water movement of about 0.1 foot per day. The Cody shale, which is the bedrock for perhaps all of the tailings area, has low transmissivity, less than 10 feet per year. This is a factor that mitigates the downward migration of seepage from the tailings ponds.

There is no naturally occurring surface water in this area with the exception of runoff during times of high precipitation. There are no perennial streams or lakes within 10 miles of the mill. Near the millsite, the water table ranges from 20 feet to more than 500 feet below the surface.

AIR

The climate is semiarid with average precipitation of less than 10 inches per year. More than 50 percent of this is during April, May, and June in the form of snow and rain. Temperatures vary from summer highs near 100°F to winter lows near minus 40°F. The seasons are distinct with mild summers and harsh winters.

The prevailing wind direction is from the west and southwest, and high winds (up to 80 miles per hour) are common. The local topography influences the daily conditions at the site including air turbulence. The blowing of particulates from the tailings ponds is mitigated in the wet and damp areas of the ponds where the moisture helps stabilize the surface. Another factor reducing windblowing is the formation of gypsum in the dry surfaces. This tends to cement the grains by forming a crust.

An environmental radiologic monitoring program is being conducted, which utilizes 33 stations for determination of suspended particles in the air, seepage from ponds, drinking water quality, and effects of uranium operations on topsoil, vegetation, and ambient airborne radioactivity. The air monitoring stations sample for total suspended particulates and for radium and its daughters, gross beta-gamma count, and numerous inorganic compounds and elements. Due to the proximity of other mills and open-pit mines (active and inactive) plus spillage from ore trucks, the actual contribution of contaminants from the tailings is difficult to impossible to distinguish from other sources.

SURFACE CONTAMINATION

The main contamination of the surface from tailings is from windblown particulates. Where the tailing piles are wet or covered with pond water, blowing of material is prevented. However, if the surfaces of the piles dry out, wind erosion can take place. Windblown tailings at the Pathfinder site are minimized by the formation of a gypsum crust at the pile surfaces, as was mentioned previously. The amount and extent of windblown materials can only be determined by radiation surveys.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

Pathfinder intends to carry out the following reclamation plan after the milling operations have been completed.

(1) Allow tailings solids to dry and conduct tests to predict settling. Pathfinder estimates from 5 to 25 years will be required to dry the tailings.
(2) Place materials excavated from mine-discharge water-settling basins and contaminated material from razing the facility into solution Pond No. 3.
(3) Place and compact a minimum of 2 feet of clay over the dried tailings.
(4) Transport suitable subsoil material to effect a 5:1 slope on tailings dam No. 2A.
(5) Place a minimum of 8 feet of suitable mine overburden over the compacted clay. (Pathfinder notes that this could change if less stringent radon regulations are adopted in the future).
(6) Place a minimum of 6 inches of suitable topsoil material over the entire tailings area.
(7) Place riprap on areas subject to erosion.
(8) Revegetate the covered areas.
(9) Implement a short-term land management plan.

In addition, mill decommissioning in accordance with License SUA-672 and applicable regulations will also be performed. Pathfinder estimates that the above plan would cost between $5 and $7 million.

DISCUSSION OF FEASIBLE COST-SHARING PLANS

Pathfinder representatives noted that Government participation in the cost of bonding to ensure final stabilization and reclamation would be equitable. This idea was extended to include the sharing of costs associated with creation of a fund for perpetual care.

The company further noted that the earthwork on the outslope of Pond 2A will benefit all tailings impounded during the operating life of the mill. The dam for Pond 4 was built in 1980-1981 and is designed to contain all the tailings impounded at the site in the case of a seismic event that could breach the upstream dams. Hence, costs related to the earthwork on Pond 2A and construction of the dam should be considered for cost-sharing as well.

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"Final Environmental Statements, Lucky Mc Gas Hills Uranium Mill," NUREG-0357, November 1977.

Production data records for the period 1948 through 1970 for mills producing uranium concentrate for sale to AEC, AEC, Grand Junction Office.

Production data records that set forth the quantities of U_3O_8 produced in domestic uranium mills in the period from December 1971 through December 1981, Grand Junction Area Office, Grand Junction, Colorado.

"Report to American Mining Congress," submitted by Pathfinder Mines, Inc., February 27, 1981.

FIGURES

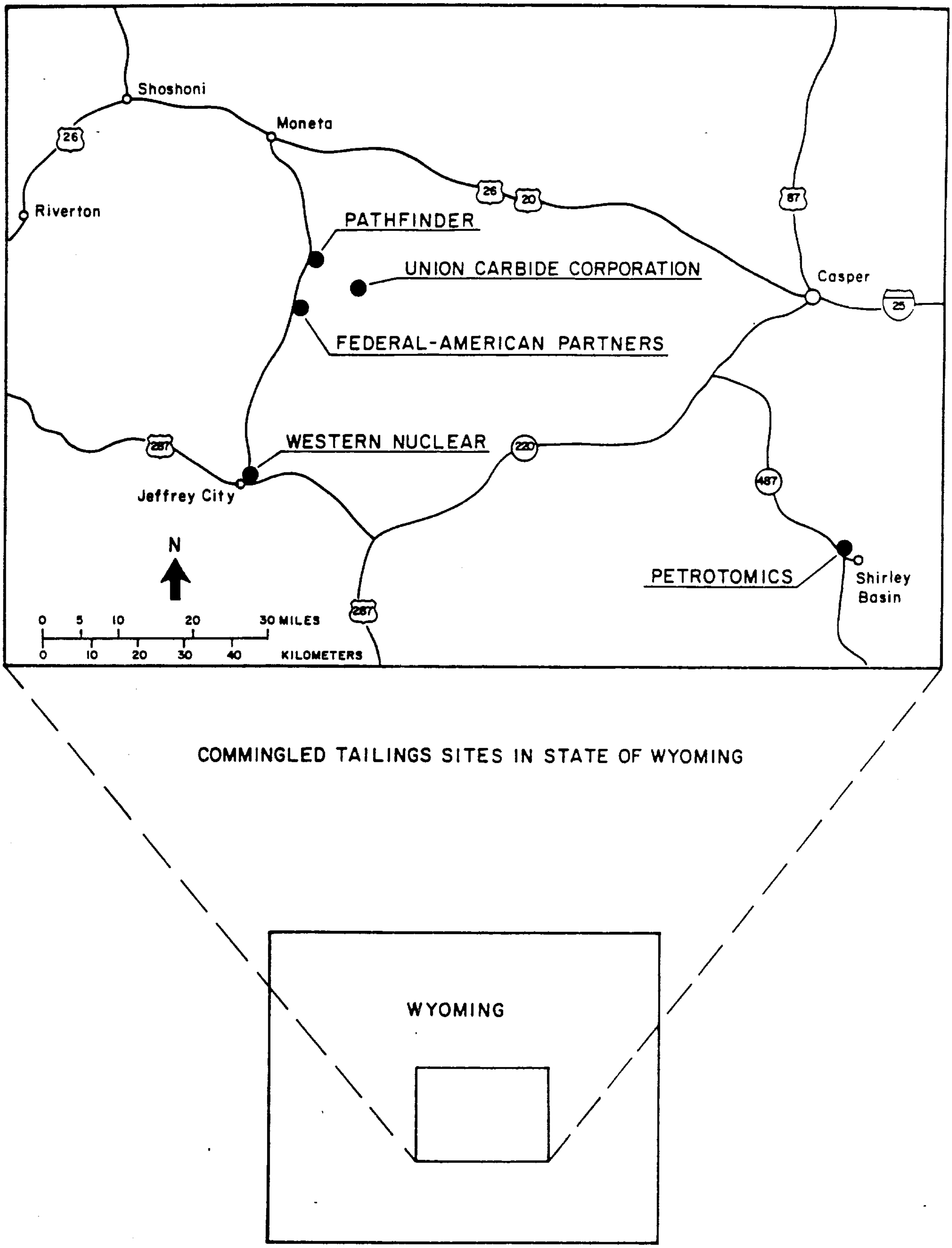

Figure 1. Location Map: Pathfinder Mines Corporation, Gas Hills, Wyoming

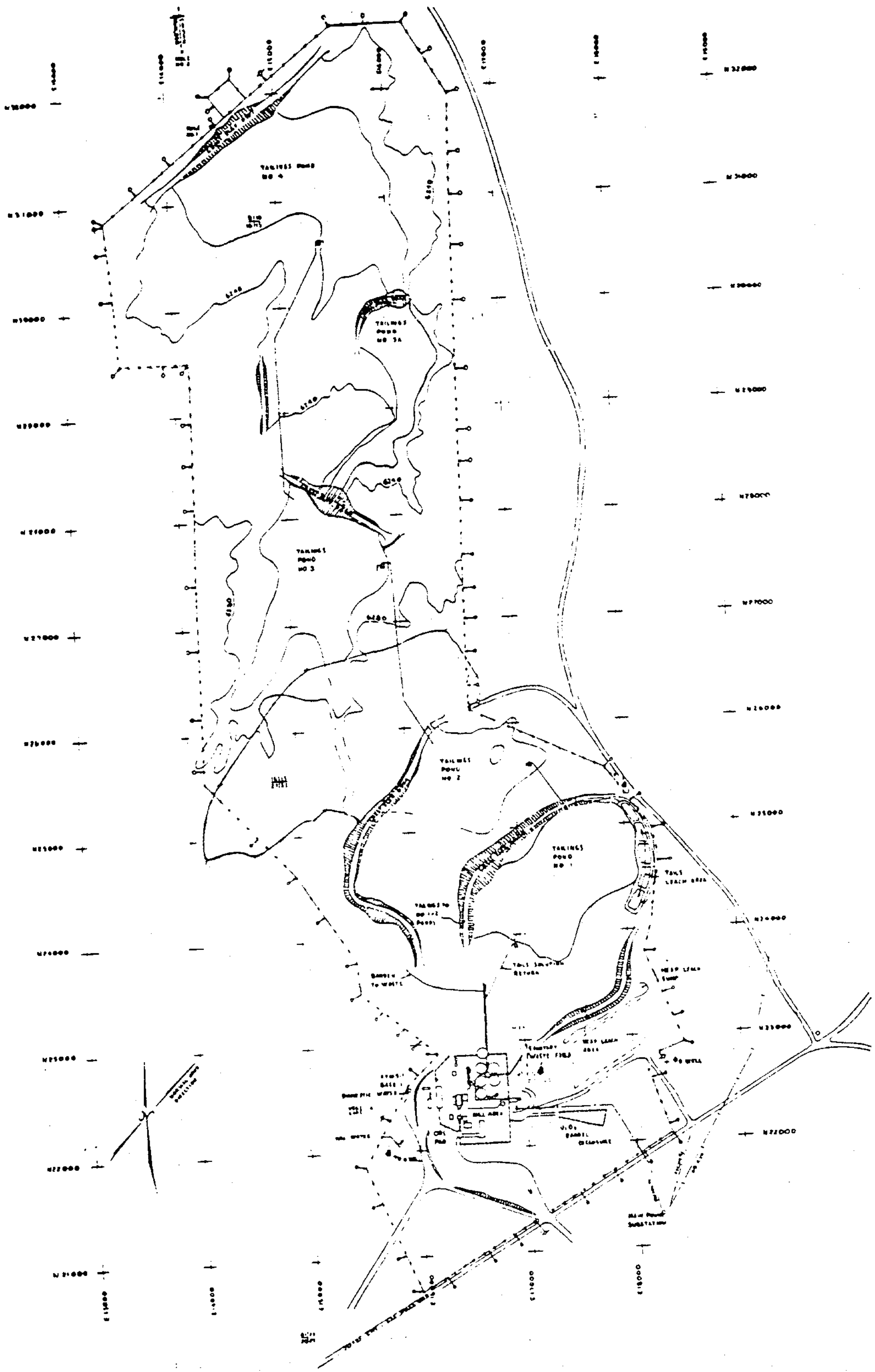

Figure 2. Plan View of the Pathfinder Millsite and Tailings Ponds

SITE REPORT: PETROTOMICS COMPANY (A UNIT OF GETTY OIL COMPANY)
Shirley Basin, Wyoming

INTRODUCTION

This report establishes the amount and condition of tailings located at Petrotomics Company's millsite in Shirley Basin, Wyoming. Because of commingling of tailings, the report provides a split between (1) those tailings attributable to the production of uranium concentrate sold to the United States for defense purposes, and (2) those tailings attributable to production of uranium concentrate for sale in the commercial market.

This report summarizes information and data received from Petrotomics operating personnel, Department of Energy (DOE) records, and from numerous professional papers, books, reports, memoranda, and letters pertinent to the report. Petrotomics provided a document entitled "Environmental Report for Source Materials License SUA-551 for the Petrotomics Mill," dated April 1, 1981, which is the primary source for environmental information appearing in this report.

BACKGROUND AND HISTORY

OWNERSHIP

Petrotomics' uranium mill and tailings pile in the Shirley Basin area of Carbon County are approximately 48 miles south of Casper, Wyoming. The mill was originally owned by a partnership of Kerr-McGee Corporation (KM), Tidewater Oil Company (Tidewater), and Skelly Oil Company (Skelly), with Getty as operating partner. Tidewater and Skelly were wholly owned subsidiaries of Getty. On September 30, 1967, Tidewater was merged into Getty, and on January 31, 1977, Skelly was merged into Getty. On November 4, 1974, KM's ownership in the mill was acquired by Getty, although KM retains certain rights to have its Shirley Basin ore bodies processed in the Petrotomics mill.

PRODUCTION HISTORY

Mill operations began in April 1962 and continued until October 1974 when the mill was temporarily closed. The mill remained closed until March 1978 when it was restarted, after being renovated in 1977-1978. Presently the mill is operating below capacity, but Petrotomics is studying a plan that would allow the mill to operate at full ore-tonnage capacity.

Petrotomics has no operating plans past the next 5 years. Petrotomics suggested the project could continue for another 12 to 15 years beyond the April 1, 1981, date of the environmental report. Using a nominal mill capacity of 1500 tons of ore per day and 340 operating days per year, it appears as though the mill could generate another 5.8 to 7.3 million tons of tailings between the end of 1981 and decommissioning.

AEC purchased uranium produced in the plant from start-up until December 31, 1966, the termination date of the contract. A total of 3,383,820.58 pounds of

U_3O_8 in concentrate was purchased by the AEC at an average price of $8 per pound. Before termination of the AEC contract, Petrotomics began producing U_3O_8 in concentrate for sale in the commercial market. The total production of U_3O_8 in concentrate from start-up through December 31, 1966, was 3,672,925 pounds from (1) 786,928 tons of ore containing 3,778,418 pounds of U_3O_8 and (2) 28,778 pounds of U_3O_8 contained in heap-leach product. From January 1, 1967, through December 31, 1981, Petrotomics continued to produce uranium for the commercial market (except for a period of shutdown from 1974 to 1978). During this period, 16,672,866 pounds of U_3O_8 in concentrate were produced from (1) 4,759,026 tons of ore containing 17,201,471 pounds of U_3O_8 and (2) 41,844 pounds of U_3O_8 contained in heap-leach product.

PROCESS DESCRIPTION AND MAJOR CHANGES

Shirley Basin Mill

Construction of the Petrotomics mill started in June 1961, and milling commenced on April 5, 1962. Nominal mill capacity was 500 tons of ore per day. The process included (1) crushing and fine ore storage, (2) grinding, (3) acid leaching, (4) countercurrent decantation washing, (5) clarification of pregnant liquor, (6) precipitation and filtration, (7) drying and packaging, and (8) tailings disposal.

In 1968, the mill capacity was expanded to 1000 tons per day by the addition of three 80-foot-diameter thickeners, leach tanks, and another solvent extraction circuit. In 1970, the mill capacity was expanded again to the present capacity of 1500 tons per day. The process did not change.

Heap Leaching

Petrotomics produced concentrated uranium liquors by heap leaching low-grade uranium material from 1966 through 1974. The residues from the heap leaching were fed to process during 1978 and 1979, and now reside within the tailings pond area.

During heap leaching, low-grade material was placed to form a 25-foot-high pile with the top shaped into 40-foot-square paddies separated by ore berms. Acidified raffinate was placed into the paddies and allowed to percolate down through the material. Pipes buried beneath the pile collected the solutions and sent them either to low-grade sumps for recirculation through the piles or to high-grade sumps for pumping to the plant solvent extraction circuit.

SITE DETAIL

LOCATION

Figure 1 shows the geographic relationship of the Petrotomics millsite (PUM) to southeast Wyoming. The millsite is located in Carbon County, Wyoming, about 120 miles west of the Nebraska border and 100 miles north of the Colorado border. Casper, the nearest major city, is approximately 48 miles north. The nearest towns to the site are Medicine Bow, about 35 miles south, and Alcova, about 35 miles northwest. The site can be reached via State Highways 220 and 487 from Casper, or Federal Highway 30/287 north from Laramie to State Highway 487. The mill and tailings impoundment area now occupy about 65 and 140 acres, respectively.

TOPOGRAPHY

The site is at an elevation of about 7100 feet and within an exclusion area of approximately 5898 acres owned by Getty. This area is fenced to prevent access by horses, sheep, and cattle. The site topography is typical of eastern Wyoming plains with moderate elevation changes, i.e., the topography of the vicinity is characterized by rolling hills and valleys. Elevation differences of 250 feet are present within 2 to 3 miles. Local slopes are 20 to 40 percent.

The Shirley Basin is a southward extension of the Wind River Basin and lies between the Sweeter Arch and the Laramie Range. The Shirley Basin area lies between the Laramie Mountains on the northeast and the Shirley Mountains on the southwest. It is an area of low to moderate relief.

Altitudes range from slightly below 6900 feet along the Little Medicine Bow River in the southeastern part of the basin to above 7800 feet on the Dugway Rim at the north boundary. The Little Medicine Bow River, a perennial stream that rises on the west flank of the Laramie Mountains, flows southward through the basin and joins the westward-flowing Medicine Bow River near the town of Medicine Bow.

Bates Hole, a prominent erosional feature in the northwestern part of the area, is drained by Stinking Creek and its tributaries. Stinking Creek is an intermittent stream that flows northward and joins the North Platte River about 30 miles northwest of the area. Relief in Bates Hole is moderate; altitudes range from about 6100 feet along Stinking Creek at the north edge of the area to slightly over 8000 feet on Chalk Mountain, near its western edge.

The Bates Creek drainage area lies north of the Shirley Basin, east of Bates Hole, and west of the Laramie Mountains. It is a high-standing, almost terrace-like area drained by northward-flowing Bates Creek. Altitudes range from about 7000 feet on the northwest to about 7800 feet on the east. Bates Creek Reservoir, in the north-central part of the area, stores water for a short time after the spring runoff, but is generally dry by midsummer.

The west flank of the Laramie Mountains extends into the northeastern part of the area. Altitudes range from about 7200 feet along the toe of the west flank of the Laramie Mountains to slightly above 8400 feet in the northeast corner of the area.

CURRENT CONDITION OF TAILINGS

Petrotomics representatives said that there is no problem with windblown tailings, because the company sprinkles in the summer to increase evaporation and to keep the tailings wet. The main reason for sprinkling is to increase evaporation. Also, a crust forms on the tailings which helps keep them in place. Air is monitored for radon gas; because of wind dilution, there is no problem.

Figures 2 and 3 are photographs taken at the time of our millsite visit in December 1981. Figure 2 gives two views of the tailings storage area, and Figure 3 provides a view of the seepage pumpback area.

QUANTITIES

Table 1 shows, from start-up through December 31, 1981, a year-by-year breakdown of (1) ore and other sources of uranium fed to process at Petrotomics' Shirley Basin mill, (2) U_3O_8 in concentrate produced, (3) U_3O_8 in concentrate sold to the AEC, and (4) price at which uranium was sold to the AEC. Subtotals are shown for the period covered by AEC purchases (start-up-December 31, 1966), and the period covered exclusively by commercial sales (January 1, 1967-December 31, 1981).

Table 2 shows the amount of tailings resulting from the production of uranium for sale to the AEC at the end of four time periods: (1) termination of the AEC contract (December 31, 1966), (2) latest date for which production data is available (December 31, 1981), (3) expected date that the present tailings pond will be full (December 31, 1983), and (4) forecast date of final shutdown of plant for decommissioning and stabilization (April 1, 1987). However, the forecast date for mill decommissioning is highly uncertain. Presently, the tailings resulting from the production of uranium for sale to the AEC represents about 13 percent of the total tailings at the Shirley Basin millsite.

TAILINGS MANAGEMENT HISTORY

Petrotomics has never had any excursions from the tailings pond. No tailings have been used as mine backfill, nor have any been moved from the site. There is only one tailings pond, where all tailings produced thus far are commingled. Solutions cover a large portion (50-75 percent) of the tailings area. There is room in this pond for the tailings generated for about another 2 years of mill operation, assuming that NRC's requirement of maintaining a 15-foot freeboard is not changed. Presently there are about 21 feet of freeboard. A new pond will be constructed if operations continue beyond 2 years.

When Petrotomics restarted the mill in March 1978, NRC required a new retention dam constructed of clayey material which fortunately was available in the overburden section of a nearby open-pit mine. The new dam cost approximately $6.5 million. In 1979, Petrotomics started forming beaches along the periphery of the dam by spigotting the tailings. These sand beaches form a shallow slope (16 to 1) with slimes flowing to the center of the pond.

In order to test for seepage, 87 holes were drilled. Eight of these are used as monitor wells. A trench was dug beyond the retention dam to intercept any seepage flow, and a pump was installed to recycle any seepage back to the tailings pond. The pumpback system is designed for up to 150 gallons per

Table 1. Amount of Ore and Other Uranium Material Fed to Process, Uranium Produced, Uranium Sold to the AEC, and Price at Which Uranium Was Sold to AEC: Petrotomics Corporation, Shirley Basin, Wyoming

	Time Period	Fed to Process: Ore, Tons	Ore, % U_3O_8	Ore, U_3O_8 (lbs.)	Other[a] U_3O_8 (lbs.)	Total U_3O_8 (lbs.)	Conc. Produced U_3O_8 (lbs.)	Sold to AEC, U_3O_8 (lbs.)	Price, \$/lb. U_3O_8
1.	Start-up-June 30, 1962	37,280	0.333	248,444	-	248,444	218,017	178,125.00	8.00
2.	July 1, 1962-June 30, 1963	166,520	0.268	892,998	-	892,998	870,227	712,500.00	8.00
3.	July 1, 1963-June 30, 1964	163,296	0.269	879,519	-	879,519	847,318	712,500.00	8.00
4.	July 1, 1964-June 30, 1965	164,499	0.232	762,406	-	762,406	745,477	713,641.23	8.00
5.	July 1, 1965-June 30, 1966	175,073	0.232	810,950	21,734	832,684	801,214	734,554.35	8.00
6.	July 1, 1966-Dec. 31, 1966	30,260	0.115	184,101	7,044	191,145	190,672	332,500.00	8.00
	SUBTOTALS	786,928	0.240	3,778,418	28,778	3,807,196	3,672,925	3,383,820.58	8.00
7.	Jan. 1, 1967-June 30, 1967	85,221	0.114	195,156	35	195,191	185,440		
8.	July 1, 1967-June 30, 1968	171,013	0.188	644,360	3,607	647,967	611,462		
9.	July 1, 1968-June 30, 1969	290,959	0.186	1,083,146	2,401	1,085,547	1,036,516		
10.	July 1, 1969-June 30, 1970	417,190	0.174	1,453,544	13,580	1,467,124	1,428,387		
11.	July 1, 1970-Dec. 31, 1970	286,290	0.190	1,087,588	7,128	1,094,716	1,017,777		
12.	Jan. 1, 1971-Dec. 31, 1971	472,269	0.240	2,262,887	5,832	2,268,719	2,183,961		
13.	Jan. 1, 1972-Dec. 31, 1972	387,601	0.246	1,908,243	4,950	1,913,193	1,799,598		
14.	Jan. 1, 1973-Dec. 31, 1973	369,113	0.227	1,676,657	3,227	1,679,884	1,726,451		
15.	Jan. 1, 1974-Dec. 31, 1974	196,474	0.173	678,486	1,084	679,570	732,698		
16.	Jan. 1, 1978-Dec. 31, 1978	428,864	0.128	1,102,170	-	1,102,170	980,264		
17.	Jan. 1, 1979-Dec. 31, 1979	562,003	0.152	1,713,722	-	1,713,722	1,714,144		
18.	Jan. 1, 1980-Dec. 31, 1980	626,664	0.145	1,811,455	-	1,811,455	1,739,365		
19.	Jan. 1, 1981-Dec. 31, 1981	465,365	0.170	1,584,057	-	1,584,057	1,516,803		
	SUBTOTALS	4,759,026	0.181	17,201,471	41,844	17,243,315	16,672,866		
	GRAND TOTAL	5,545,954	0.189	20,979,889	70,622	21,050,511	20,345,791		

[a] U_3O_8 in heap-leach product produced on-site and sent to the plant solvent extraction circuit for final processing.

Table 2. Amount of Tailings, Area Covered, and Height of Piles at Petrotomics' Shirley Basin Mill at Various Dates

	12/31/66	12/31/81	12/31/83[a]	4/1/87[b]
Tailings (short tons):				
AEC Contract[c]	724,987	724,987	724,987	724,987
Commercial Sales	61,941	4,820,967	5,840,967	7,566,760
Totals	786,928	5,545,954	6,565,954	8,291,747
AEC Contract, Percent of Total	92	13	11	9
Area Covered (acres)	50	140	140	140
Pile Height (feet)	5.5	35	40	50

[a]Expected date that the present tailings pond will be full, that is, leaving a 15-foot freeboard as required by NRC.

5,545,954 (as of 12/31/81) + (1500 TPD x 340 days/yr. x 2 yrs.) = 5,545,954 + 1,020,000 = 6,565,954 tons

[b]Projected end of the life of the impoundment. Based on 6 years of full capacity operation beyond April 1, 1981.

5,231,747 (as of 3/31/81) + (1500 TPD x 340 days/yr. x 6 yrs.) = 5,231,747 + 3,060,000 = 8,291,747

[c]Based on proportion of pounds of U_3O_8 in concentrate sold to AEC and total pounds of U_3O_8 in concentrate produced through December 31, 1966.

$$786{,}928 \text{ tons of ore fed to process} \times \frac{3{,}383{,}820.58 \text{ lbs. } U_3O_8 \text{ sold to AEC}}{3{,}672{,}925 \text{ lbs. } U_3O_8 \text{ produced}} = 724{,}987 \text{ tons}$$

minute. Petrotomics' representatives said that there is no seepage below a natural clay barrier beneath the tailings pond, nor is there any seepage to the Little Medicine Bow River due to Petrotomics' operations.

Petrotomics would prefer the new tailings disposal to be below grade. They believe a synthetic lining is too expensive and would be ineffective in the long term. Petrotomics has never neutralized tailings, but may be willing to do so if it were economically feasible and would allow below-grade impoundment of tailings in unlined ponds.

ENVIRONMENTAL CONSIDERATIONS

During the last license renewal of Source Material License SUA-551, the NRC prepared an environmental impact appraisal for the Petrotomics uranium milling facility. The commission concluded that "on the basis of this appraisal, the environmental impact created by the renewal of the license is of a magnitude not warranting an environmental impact statement for the proposed section, and that a negative declaration to this effect is appropriate." Petrotomics' personnel indicate that, since this letter was issued, very little, if any, change has taken place in the environment in Shirley Basin. Petrotomics summarizes the environmental effects that cannot be avoided as follows:

> Small quantities of radioactive and nonradioactive materials are released into the environs surrounding the plant and small amounts of U_3O_8 are deposited onto the mill property and on vegetation and soil in unrestricted areas downwind from the mill. However, the release of such small quantities does not cause a significant impact on the environment.
>
> The local ground water system will be slightly disturbed for a period of 12-15 years due to the mining operation. Since the area is sparsely populated and remote, the impact is expected to be minimal.
>
> The relocation of earth from open pit mining and the formation of a tailings pond resulted in a change in the local topography. Following reclamation and restoration, this change will not be noticeable. There will be a change of the plant life system in the immediate area of the mine and the mill for a period of 12-15 years. However, the revegetation program will definitely reestablish suitable vegetation in the area. Changes in the animal life of the area are expected to be minimal.

DEMOGRAPHY

The area surrounding Petrotomics' Shirley Basin millsite is quite sparsely populated. The largest population center within 50 miles of the millsite is Casper, 48 miles to the north, with a 1980 population of about 58,000. The trailer village of Shirley Basin, where uranium mine and mill workers and their families reside, is about 2 miles south of the millsite and had a population of about 700 in 1980.

WATER

No farming activities are conducted in this semidesert wilderness area as the growing season is short and natural moisture levels are inadequate for economical agriculture. At the conclusion of mining and milling, the land will be returned to natural contour and its original land use of sheep and cattle grazing and wildlife habitat. The addition of water impoundments should enhance these uses and add to the recreational value of the land.

The White River Formation overlies the Wind River in the vicinity and they are generally separated by a thin layer of clay. Water levels near the mine pits in both the Wind River and White River aquifers have been significantly lowered due to mine dewatering in the Shirley Basin. When mining ceases, the pit dewatering will also cease, and the water levels will recover to an elevation close to that which existed before mining.

White River aquifer water is moderately hard to hard with total dissolved solids relatively low (less than 326 mg/l). Wind River aquifer water is moderately hard to very hard with total dissolved solids concentrations ranging from 315 mg/l to greater than 1400 mg/l.

The quality of the White River aquifer water is generally good for most prospective uses. Several well water samples contained iron and manganese concentrations higher than recommended for a public or domestic water supply; however, these recommendations are based mainly on aesthetic criteria. Ammonia-nitrogen concentrations were high enough in several samples that they "warrant concern if water is to be used for domestic or aquatic-life purposes."

Chemical constituents that have been observed in the Wind River aquifer wells in concentrations greater than those recommended by the EPA for domestic or aquatic-life purposes include bicarbonate, cadmium, chromium, iron, lead, manganese, mercury, and ammonia-nitrogen.

The local surface drainage area of the Petrotomics uranium mill is quite limited. The millsite is in a low-precipitation area with the major runoff occurring in the May and June period of snow melt and rain. There are two perennial streams in the nearby area. The Little Medicine Bow River and the lower reach of Sand Creek have cut below the main ground-water body. The drainage area below the tailings is part of the Sand Creek drainage system. Sand Creek is approximately 2 miles from the mill. There is no liquid effluent discharged into the stream drainage by the Petrotomics uranium mill.

AIR

The climate of the Basin is arid to semiarid, with low annual precipitation and a frost-free growing season of 90 to 110 days. Temperatures are moderately warm during the summer months and cold in the winter. Extreme fluctuations in temperatures from day to day, and in annual rainfall from year to year, are common. These climatic variations have a strong effect on vegetation and in determining land capabilities and use. Summers are accompanied by the prevailing southwesterly winds that become stronger as fall approaches. The winter winds are often out of the northwest, creating blizzard conditions.

The average annual precipitation in Casper is about 11 inches with the highest recorded precipitation of 16.24 inches in 1941, and the lowest of 7.34 inches in 1960. The average annual snowfall in Casper is about 72 inches. The maximum was about 117 inches in the winter of 1972-1973.

More than half of the annual precipitation occurs during April, May, and June in the form of wet snows and rain. Temperatures vary from summer highs near 100°F to winter lows near -40°F. The seasons are distinct, with mild summers and harsh winters. Spring and fall are transition seasons, with warm days and cool nights; wet, heavy snowfalls can be expected during both these seasons. The prevailing wind direction is from the west and southwest. Strong winds occasionally occur. The strongest recorded speed for Casper was 81 miles per hour from the southwest in March 1956.

Local topography strongly influences the micrometeorological conditions at the site. The degree of dilution of airborne contaminants from normal operating releases is determined by small-scale turbulence in the local area in combination with the prevailing wind.

Tornadoes occasionally occur but tend to be somewhat less destructive than those occurring farther east. Only one tornado has been reported within 50 miles of the site since 1950.

Data on background levels of air pollutants at the Petrotomics site are lacking. However, the area's low population density and lack of industrial and other pollution sources, combined with the good ventilation characteristics of the atmosphere, make the air quality good. The sparseness of the vegetative cover may lead to high values of suspended particulate material during periods of high wind speeds.

Petrotomics monitors the air for radon gas; because of wind dilution, there is no problem.

SURFACE CONTAMINATION

Petrotomics' representatives said that there is no problem with windblown tailings as a sprinkling system is used in the summer to increase the evaporation of liquids from the impoundment and to keep the exposed tailings wet. The tailings which are exposed and have dried out have a stabilizing residue (principally gypsum) which is not subject to dusting.

Ore crushing is accomplished in two stages, first by a jaw crusher and then by a hammermill. In both processes, baghouse dust collectors are used, with the collected dust redeposited on the conveyor belt going to storage.

The area around the mill is paved. Dusting is kept to a minimum by watering the haulage roads during dry, windy periods.

Dust and vapors from concentrate drying and packaging, and from other parts of the milling process, are passed through air cleaning scrubbers. Vapors from the dryer are predominantly ammonia and water, and dust from the dryer is uranium concentrate. Scrubber efficiency is kept high (greater than 99 percent) as any reduced efficiency results in not only contamination to the environment, but also means a loss in mill product.

DISCUSSION OF VIABLE STABILIZATION PLANS

Petrotomics will be required to conduct decommissioning and reclamation activities at the millsite in accordance with conditions of its NRC source materials license. Petrotomics entered a surety agreement with Seaboard Surety Company in the amount of $1,928,860 (1981 dollars) to provide for tailings stabilization and mill decommissioning. The bond is held by the Wyoming Department of Environmental Quality, Land Quality Division.

In accordance with Section 202 of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), standards for uranium tailings stabilization have been promulgated by NRC, effective November 1981 (45 CFR, p. 65521). They are to be consistent with standards of general applicability yet to be issued by EPA under UMTRCA. These final NRC rules are being challenged by the American Mining Congress and others.

Petrotomics has submitted decommissioning plans to the NRC which call for (1) removal of all buildings, structures, and pipelines; (2) disposal of all materials that cannot be decontaminated in accordance with NRC standards by using measures in compliance with Federal regulations; (3) breaking up and burying all foundations; and (4) contouring, topsoiling, and revegetating the affected area.

Tailings reclamation plans provide for (1) allowing the tailings to dry out sufficiently to permit the use of heavy earth-moving equipment over them; (2) capping the tailings with 6-1/2 feet of clay available from adjacent mine areas; (3) placing 1/2 foot of topsoil over the clay capping; and (4) fertilizing and revegetating with appropriate plant species. Following reclamation, a monitoring and maintenance program will be established to ensure stability.

NRC requires that $250,000 (1980 dollars) be paid to the General Treasury of the United States or to an appropriate state agency prior to termination of the mill license to cover the cost of long-term surveillance. Petrotomics' representatives said that they will not address this requirement until the end of milling.

Petrotomics' personnel estimated that the cost of reclamation for the tailings that would exist at the end of another 2 years of operations has been estimated at approximately $1 million. This estimate provides for (1) 6-1/2 feet of cover, (2) 1/2 foot of topsoil, and (3) seeding with native grasses. This estimate does not provide for either 10-to-1 or 5-to-1 slopes, which could cost $10 to $15 million.

It should be noted that the plan submitted to NRC calls for 6-1/2 feet of clay compared to 3 meters of cover provided in the cost estimate.

DISCUSSION OF PROPOSED COST-SHARING PLANS

Petrotomics had no comments pertaining to the "cost formula" which would provide Government assistance in the stabilization and management of uranium mill tailings resulting from ore processing to extract uranium under contract with the United States. Petrotomics would rather have "help for test work, etc., which would resolve unanswered questions on disposal of tailings below grade."

PERTINENT AEC CONTRACT PROVISIONS

AEC first purchased U_3O_8 in concentrate produced in the Petrotomics mill under Contract No. AT(05-1)-790. This contract was entered into August 12, 1960, with an effective date of April 1, 1960, and a termination date of December 31, 1966 (plus an opportunity to deliver final concentrates until close of work February 2, 1967). Under the provisions of the contract, Petrotomics agreed, among other things, to construct and operate the mill and deliver the product, U_3O_8 in concentrate, to the AEC at Grand Junction, Colorado. The contractor was allowed to produce the uranium contract quantities in a plant owned or controlled by it, or to arrange for the production in facilities owned or controlled by others but which were operated for production and sale of uranium concentrate under contract with the AEC. AEC agreed, among other things, to purchase a maximum of 3,185,750 pounds of U_3O_8 in concentrate plus 95 percent of U_3O_8 in ore in stockpile as of March 31, 1962. The price was fixed at a flat $8 per pound of U_3O_8 in concentrate, in accordance with program policy calling for a fixed price of $8 per pound of U_3O_8 for all uranium purchased by AEC between April 1, 1962, and December 31, 1966.

Petrotomics chose not to participate in AEC's stretch-out program which invited U.S. uranium producers to defer to the years 1967 and 1968 a portion of the concentrates originally contracted for delivery by December 31, 1966, and to sell to the AEC in 1969 and 1970 an additional quantity of uranium in concentrate equal to the amount deferred and delivered in 1967 and 1968.

REFERENCES

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"The Petrotomics Uranium Mill, Shirley Basin, Wyoming," Frank A. Seeton, Bulletin No. M4-B115, Denver Equipment Company, October 1962.

Production Data Books, a compilation of uranium production data in the Western United States for the period 1948 through 1970, by the Grand Junction Office of the U.S. Atomic Energy Commission.

Section 213 Public Law 96-540, December 17, 1980.

FIGURES

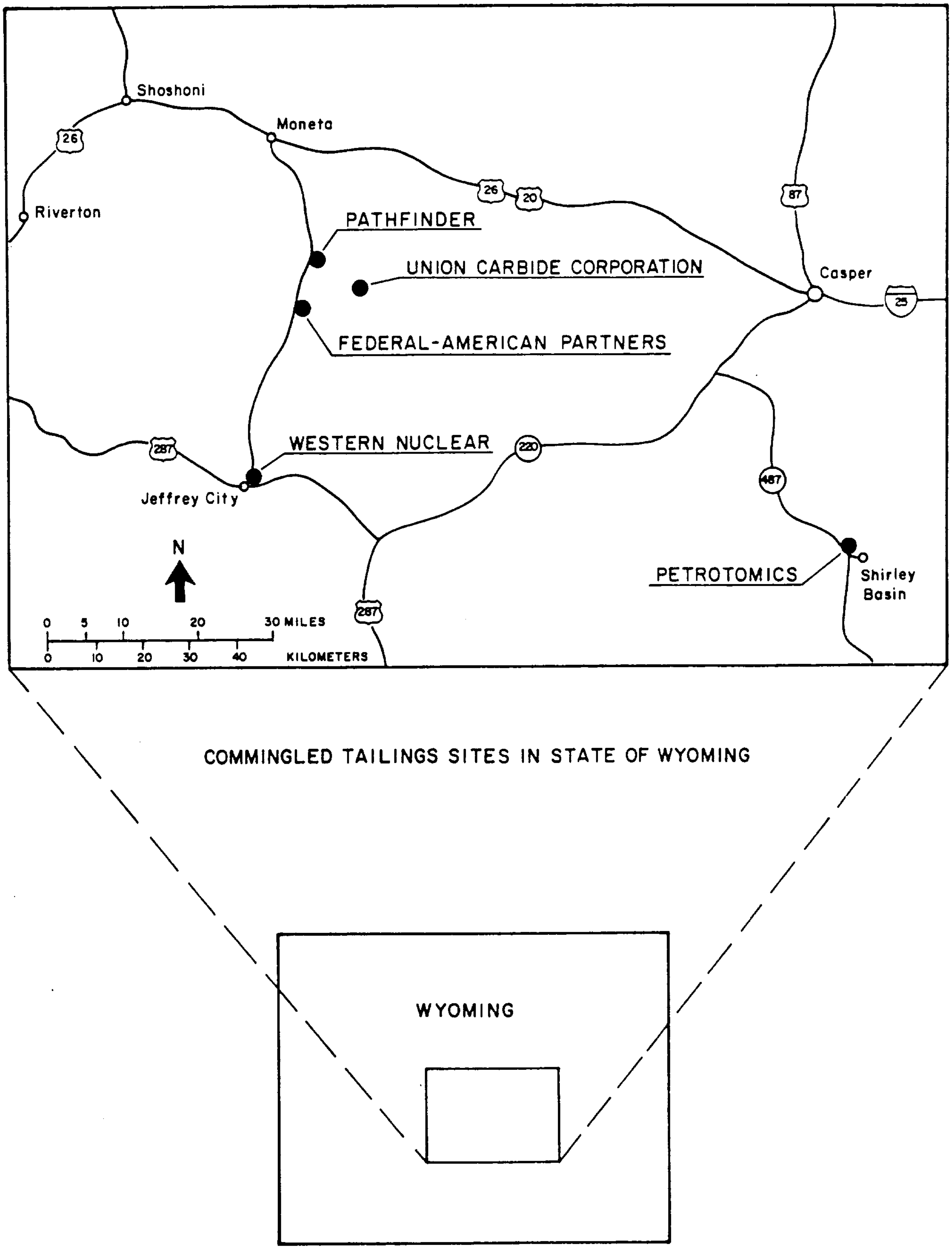

Figure 1. Location Map: Petrotomics Uranium Mill, Shirley Basin, Wyoming

SITE REPORT: UNION CARBIDE CORPORATION
Gas Hills, Wyoming

INTRODUCTION

This report establishes the amount and condition of tailings located at Union Carbide Corporation's (UCC) millsite in the Gas Hills, Wyoming. Because of commingling of tailings, the report provides a split between (1) those tailings attributable to the production of uranium concentrate sold to the United States for defense purposes, and (2) those tailings attributable to production of uranium concentrate for sale in the commercial market. The UCC Gas Hills millsite was visited to observe actual impoundment conditions and to discuss past and current tailings disposal practices with company officials.

This report provides summaries of information and analyses of data obtained from UCC, Department of Energy (DOE) records, and from numerous books, reports, memoranda, letters, and telephone calls pertinent to the report. The Nuclear Regulatory Commission's (NRC) final environmental statement for UCC's Gas Hills mill was relied on heavily.

BACKGROUND AND HISTORY

OWNERSHIP

Union Carbide Corporation owns a uranium mill and tailings piles at Gas Hills, Wyoming, in Natrona County, approximately 50 miles southeast of Riverton, Wyoming. The mill was constructed and originally operated by Globe Mining Company, a wholly owned subsidiary of UCC. UCC owns the land on which the mill is located. Insofar as can be determined, the tailings piles are located on unpatented lode mining claims on Federal lands.

UCC also owns and operates heap-leaching facilities at the millsite. High-grade product liquor is produced from low-grade ore and sent to the mill for further processing.

PRODUCTION HISTORY

Mill operations began in January 1960 and were continuing at the time of the visit to the site on October 29, 1981. UCC personnel were reluctant to discuss future mill operations except to say they are indefinite. The Nuclear Regulatory Commission's final environmental statement dated July 1980 stated, "The applicant has determined, however, that it will be economical to process only 2.5 million tons of this ore." By taking into account actual ore fed to process from July 1, 1980, through June 1981, a nominal mill capacity of 1600 tons per day, and 330 operating days per year, it appears as if the mill may be able to operate until about July 1985. Of course, as pointed out by UCC personnel, no one knows what uranium prices or production costs will be in the future.

AEC purchased uranium produced in the plant from start-up until December 31, 1970, the termination date of the contract. A total of 5,617,289.04 pounds of

U_3O_8 in concentrate was purchased by the AEC at an average price of about $7.69 per pound. Before termination of the AEC contract, UCC began producing U_3O_8 in concentrate for sale in the commercial market. The total production of U_3O_8 in concentrate from start-up through December 31, 1970, was 6,579,903 pounds from (1) 2,463,809 tons of ore containing 7,131,888 pounds of U_3O_8 and (2) 2898 pounds of U_3O_8 contained in heap-leach product.

From January 1, 1971, through December 31, 1981, UCC continued to produce uranium for the commercial market. During this period, 10,594,634 pounds of U_3O_8 in concentrate were produced from (1) 4,781,347 tons of ore containing 10,618,659 pounds of U_3O_8 and (2) 1,017,485 pounds of U_3O_8 contained in heap-leach product.

PROCESS DESCRIPTIONS AND MAJOR CHANGES

Gas Hills Mill

Construction of UCC's original Gas Hills mill started in mid-1959, and the plant was placed into operation in January 1960. Nominal mill capacity was 500 tons per day. The process used included (1) receiving, crushing, and fine ore storage, (2) grinding, (3) acid leaching, (4) sand-slime separation, (5) continuous countercurrent resin-in-pulp (RIP), (6) solvent extraction, (7) precipitation, (8) filtration, drying, and packaging, and (9) tailings disposal.

Heap Leaching

UCC operated an experimental heap leach at the Gas Hills millsite from 1963 to 1966. The full-scale heap-leach operation began in 1979. The heap-leach operation consists of preparation of the heap-leach pads, circulation of sulfuric acid solutions to attain the required buildup of uranium recovery of the uranium in a solvent extraction circuit, and pumping the organic phase to the stripping section of the conventional mill circuit.

In 1977, UCC started sending to the Gas Hills mill uranyl carbonate solutions from its Maybell, Colorado, heap-leaching operations. After arrival at the mill by tank truck, the solutions enter the circuit at the solvent extraction phase of the mill circuit. The heap-leaching operations performed at Maybell are similar to those described for heap leaching at the Gas Hills millsite.

SITE DETAIL

LOCATION

Figure 1 shows the geographic relationship of UCC's Gas Hills millsite to the State of Wyoming. The mill is located in Natrona County, Wyoming, adjacent to the Natrona County/Fremont County boundary. The site is in a remote area of central Wyoming approximately 60 miles west of Casper, 50 miles southeast of Riverton, 23 miles south of Montea, and 75 miles north of Rawlins. The millsite, ancillary facilities, and tailings area currently occupy about 235 acres.

TOPOGRAPHY

The UCC Gas Hills mill and heap-leach site are in the Gas Hills mining district in the southeast portion of the Wind River Basin, which is both a topographical and structural basin. Elevations in the basin range from 4300 feet at the northern end of the Wind River Canyon to more than 13,000 feet at the crest of the Wind River Mountains. North and west of the site, the form of the land ranges from gently rolling plains to deeply dissected stream valleys.

The dominant topographical features in the vicinity of the site are the Rattlesnake Hills to the east, the hogback ridges of the northwesterly plunging Gas Hills Anticline, and the steep, northeasterly trending Beaver Divide escarpment in the southern margin of the basin. The lip of the Beaver Divide escarpment is essentially the drainage divide between the northward-flowing tributaries of Wind River and the southward-flowing tributaries of the Sweetwater River.

The millsite is on a gently sloping, plateau-like remnant of the Beaver River that extends northward to the Wind River Basin. Elevations at the site range from 6900 to 7000 feet.

CURRENT CONDITION OF TAILINGS

Figures 2 and 3 are photographs, taken in October 1981, showing the operative and the inoperative tailings piles, respectively, at UCC's Gas Hills millsite. Figure 2 shows the below-grade operative tailings pile, and Figure 3 shows the above-grade inoperative tailings pile. The inoperative piles resulted from processing ore for uranium sales to both the AEC and the commercial market, and thus are commingled tailings. The operative piles resulted from processing ore for the commercial market only.

The inoperative pile ranges up to 50 feet in height from natural ground level and occupies an area of about 146 acres. Total impacted area is estimated at 168 acres.

Figure 4 is a photograph, also taken in October 1981, of one of the two solution evaporation ponds used in conjunction with the operative below-grade tailings pile shown in Figure 2. Mill solutions are pumped from the below-grade tailings pile to the evaporation ponds, and then either recycled back to the mill or evaporated into the atmosphere.

At the time of the millsite visit, it wasn't readily apparent if any tailings had been blown outside the immediate retention area of the inoperative pile. Some interim stabilization has been done using waste. We were told that this minimizes radiation emission and blowing of sands.

QUANTITIES

Ore Tailings

Table 1 shows, from start-up through December 31, 1981, a year-by-year breakdown of (1) ore and other sources of uranium fed to process at UCC's Gas

Table 1. Amount of Ore and Other Uranium Material Fed to Process, Uranium Produced, Uranium Sold to AEC, and Prices at Which Uranium Was Sold to AEC - Union Carbide Corporation, Gas Hills, Wyoming

		Fed To Process								
		Ore			Other Uranium Material Heap Leach					
	Time Period	Tons	% U_3O_8	U_3O_8 (lbs.)	Maybell (lbs. U_3O_8)	Gas Hills (lbs. U_3O_8)	Total U_3O_8 (lbs.)	Conc. Produced, U_3O_8 (lbs.)	Sold to AEC, U_3O_8 (lbs.)	Price, $/lb. U_3O_8
1.	Start-up - June 30, 1960	108,301	0.177	383,065	-	-	383,065	350,303	324,927.99	8.39
2.	July 1, 1960-June 30, 1961	263,349	0.146	767,480	-	-	767,480	673,337	650,738.00	8.30
3.	July 1, 1961-June 30, 1962	258,961	0.137	711,216	-	-	711,216	687,417	651,764.18	7.91
4.	July 1, 1962-June 30, 1963	201,202	0.176	708,491	-	641	709,132	653,904	650,738.00	8.00
5.	July 1, 1963-June 30, 1964	185,357	0.175	647,781	-	956	648,737	583,547	617,022.12	8.00
6.	July 1, 1964-June 30, 1965	132,692	0.191	507,722	-	696	508,418	480,908	463,071.88	7.99
7.	July 1, 1965-June 30, 1966	141,698	0.178	505,418	-	519	505,937	473,852	501,096.47	8.00
8.	July 1, 1966-June 30, 1967	165,804	0.143	473,636	-	86	473,722	453,303	431,430.40	8.00
9.	July 1, 1967-June 30, 1968	189,750	0.104	395,279	-	-	395,279	374,572	379,000.00	8.00
10.	July 1, 1968-June 30, 1969	231,712	0.131	606,877	-	-	606,877	548,333	379,000.00	6.69
11.	July 1, 1969-June 30, 1970	365,918	0.134	979,039	-	-	979,039	904,012	379,000.00	5.37
12.	July 1, 1970-Dec. 31, 1970	219,065	0.102	445,884	-	-	445,884	396,415	189,500.00	5.37
	SUBTOTALS	2,463,809	0.145	7,131,888	-	2,898	7,134,786	6,579,903	5,617,289.04	7.69
13.	Jan. 1, 1971-Dec. 31, 1971	356,193	0.087	616,894	-	271	671,165	560,946		
14.	Jan. 1, 1972-Dec. 31, 1972	392,452	0.112	882,066	-	-	882,066	782,124		
15.	Jan. 1, 1973-Dec. 31, 1973	390,886	0.121	948,709	-	3,626	952,335	842,825		
16.	Jan. 1, 1974-Dec. 31, 1974	393,456	0.115	907,717	-	31,147	938,864	851,090		
17.	Jan. 1, 1975-Dec. 31, 1975	421,993	0.118	992,507	-	41,151	1,033,658	958,901		
18.	Jan. 1, 1976-Dec. 31, 1976	497,351	0.118	1,177,378	-	-	1,177,378	1,062,915		
19.	Jan. 1, 1977-Dec. 31, 1977	497,650	0.127	1,264,498	139,266	22,532	1,426,296	1,329,834		
20.	Jan. 1, 1978-Dec. 31, 1978	515,244	0.105	1,086,539	177,673	16,948	1,281,160	1,181,745		
21.	Jan. 1, 1979-Dec. 31, 1979	504,234	0.101	1,019,643	62,338	103,558	1,185,539	1,091,596		
	SUBTOTALS	3,969,459	0.112	8,895,951	379,277	219,233	9,494,461	8,661,976		
22.	Jan. 1, 1980-Dec. 31, 1980	546,250	0.106	1,160,971	-	120,269	1,281,240	1,152,548		
23.	Jan. 1, 1981-Dec. 31, 1981	265,638	0.106	561,737	190,559	108,147	860,443	780,110		
	SUBTOTALS	811,888	0.106	1,722,708	190,559	228,416	2,141,683	1,932,658		
	GRAND TOTAL	7,245,156	0.122	17,750,547	569,836	450,547	18,770,930	17,174,537		

[a]In addition, 756,338 pounds U_3O_8 in nonspecification concentrate produced at UCC's Uravan, Colorado, mill was refined in the Gas Hills mill with an estimated recovery of 99 percent. Approximately 25,000 tons of material were heap leached during the period 7/1/62-6/30/67. Approximately 250,000 tons were heap leached during the period 1/1/73-12/31/75, of which 95,000 tons were hauled to a new heap-leach site where 735,000 tons are presently being heap leached.

Hills mill, (2) U_3O_8 in concentrate produced, (3) U_3O_8 in concentrate sold to AEC, and (4) price at which U_3O_8 in concentrate was sold to the AEC. Subtotals are shown for the period covered by AEC purchases (start-up-December 31, 1970) and the period covered exclusively by commercial sales (Janaury 1, 1971-December 31, 1981).

Table 2 (on next page) shows the amount of tailings resulting from the production of uranium from ore for sale to the AEC as of (1) termination of the AEC contract (December 31, 1970), (2) the end of operations during which tailings were sent to the above-grade tailings ponds (December 31, 1979), (3) latest date that production data are available (December 31, 1981), and (4) forecast date of final plant shutdown for decommissioning (June 30, 1985). Table 2 also shows the tailings broken into the two subcategories of "operative" and "inoperative." "Operative" and "inoperative" refer to the status of the tailings piles as of the date of this report, that is, whether the piles were active or inactive.

As of December 31, 1981, the tailings resulting from the production of uranium for sale to the AEC represent about 33 percent of the tailings in the inoperative piles and about 29 percent of the total tailings in both the inoperative and operative piles.

At the estimated time of mill decommissioning, the tailings resulting from the production of uranium for sale to the AEC represent about 23 percent of the total tailings in both the inoperative and operative piles.

Heap-Leach Tailings

Table 3 shows the amount of tailings resulting from the production of uranium from heap leaching of low-grade material for sale to the AEC as of (1) termination of the AEC contract (December 31, 1970), (2) end of operations during which residues from heap leaching were placed in the above-grade tailings pond (December 31, 1979), and (3) latest date for which production data are available (December 31, 1981).

Table 3. Amount of Heap-Leach Tailings at UCC Gas Hills, Wyoming, Mill[a]

	12/31/70 Inoperative	12/31/79 Inoperative	12/31/81 Inoperative	12/31/81 Operative	12/31/81 Total
Heap-Leach Waste (short tons)					
AEC Contract	21,300	21,300	21,300	0	21,300
Commercial Sales	3,700	176,000	176,000	735,000	911,000
Totals	25,000	197,300	197,300	735,000	932,300

[a]"Operative" and "Inoperative" refer to active or inactive status, respectively, of the tailings piles as of the date of the report.

Table 2. Amount of Tailings, Area Covered, and Height of Piles at Union Carbide's Gas Hills Mill at Various Dates[a]

	12/31/70	12/31/79	12/31/81			6/30/85[b]		
	Inoperative	Inoperative	Inoperative	Operative	Total	Inoperative	Operative	Total
Tailings (short tons):								
AEC Contract[c]	2,103,363	2,103,363	2,103,363	0	2,103,363	2,103,363	0	2,103,363
Commerical Sales	360,446	4,329,905	4,329,905	811,888	5,141,793	4,329,905	2,784,414	7,114,319
Totals	2,463,809	6,433,268	6,433,268	811,888	7,245,156	6,433,268	2,784,414	9,217,682
AEC Contract, Percent of Total	85	33	33	0	29	33	0	23
Area Covered (acres)	60	146	146			146		
Pile Height (feet)	up to 40	up to 50	up to 50			up to 50		

[a]"Operative" and "Inoperative" refer to active or inactive status, respectively, of the tailings piles as of the date of the report.

[b]DOE forecast of possible date of mill decommissioning. Based on (1) NRC's comment in the final environmental statement for UCC's Gas Hills project relating to expected life (2,500,000 tons as of July 1, 1980), (2) 401,496 tons fed to process from July 1, 1980, to June 30, 1981, (3) an average operating rate of 1600 tons per day, and (4) 330 days of operation per year.

[c]Based on proportion of pounds of U_3O_8 in concentrate sold to AEC and total pounds U_3O_8 in concentrate produced through December 31, 1970, i.e.,

$$2{,}463{,}809 \text{ tons of ore fed to process} \times \frac{5{,}617{,}289 \text{ pounds of } U_3O_8 \text{ sold to AEC}}{6{,}579{,}903 \text{ pounds of } U_3O_8 \text{ produced}} = 2{,}103{,}363$$

TAILINGS MANAGEMENT HISTORY

Figure 5 shows the locations of the original and the additions to the inoperative above-grade tailings pile at UCC's Gas Hills millsite.

From the start of operations in 1960 until the end of the Federal Government contracts at the end of 1970, tailings were deposited in the area referred to on Figure 5 as "Original Tailings Pond and 1969 Addition." Figure 6 is an aerial photograph of these tailings taken May 11, 1970. The area of the tailings as of the end of 1970 is estimated at about 60 acres and the height is estimated to be up to 40 feet above natural ground. The area includes an earthern dike built to contain the tailings. Additional tailings resulting from production of uranium for private sales were deposited in this area from 1971 to 1979.

Two other tailings disposal areas, referred to as "1972 Tailings Pond Addition" and "1974 Tailings Pond Addition" on Figure 5, were constructed contiguous to the original tailings pile. Tailings were deposited in these areas until the end of 1979. Figure 7 is an aerial photograph of these tailings, taken April 19, 1980.

The area of the inoperative above-grade tailings pile presently is 146 acres and has a height of up to 50 feet above ground level. Total impacted area is estimated at 168 acres.

ENVIRONMENTAL CONSIDERATIONS

DEMOGRAPHY

The area surrounding UCC's Gas Hills mill is sparsely populated. The largest population center within 50 miles of the millsite is Riverton, slightly less than 50 miles to the northwest, with a 1977 estimated population of about 10,000. The closest population center of more than 25,000 is Casper, about 60 miles east of the mill. Shoshoni, with a 1970 population of about 600, is 42 miles to the northwest of the site.

WATER

Ground water occurs in the Wind River Formation both under confinement and as unconfined perched water. Ground water in the pre-Tertiary strata is confined. Recharge to the Wind River Formation is believed to be principally from direct precipitation and intermittent stream flow in the vicinity.

The Tensleep and Cloverly Formations are the primary aquifers in the site vicinity, and supply culinary and industrial water for the UCC's Gas Hills mill. Approximately 5 miles west of the site, a number of wells obtain water from the Phosphoria-Tensleep Formations, the Cloverly Formation, the lower Wind River Formation, and stream bottom alluvium.

A number of low-yield springs are located in the site vicinity which provide water for wildlife and livestock. No water rights are available on these springs.

There have been no excursions from the ponds. NRC's final environmental statement for UCC's Gas Hills mill indicates that seeps and East Canyon Creek flow in the mill vicinity were high in total dissolved solids, nitrates, sulfate, and, in some areas, ammonia. Drinking water regulations were exceeded at all sample points for sulfate. The only known use for surface water in the region of the mill at the time of issuing the environmental statement was for stock watering purposes. It was expected that surface-water-quality degradation would be reduced by the abandonment and reclamation of the above-ground tailings pond.

Process waste liquids, containing spent chemicals from milling operations, are pumped as a slurry to tailings disposal. The water associated with the tailings is acidic, contains a number of metallic compounds in solution, and has a high dissolved-solids content. The tailings slurry also contains a small portion of the organic phase from the solvent extraction process. This organic residue is retained in the tailings as a film attached to the solid particles.

AIR

The climate of the Gas Hills region of Central Wyoming is semiarid, with the average annual precipitation ranging from 8 to 16 inches, much of which is received during the months of May, June, and July from thunderstorms. Seasons are distinct, with mild summers and harsh winters. Summer temperature highs are near 100°F, and winter lows near -40°F. Spring and fall are transition seasons, with warm days and cool nights.

The prevailing wind direction is westerly to southwesterly. Strong winds are frequent throughout the year. Wind data from Casper, about 60 miles to the east of the millsite, are the most representative available. Mean and maximum monthly wind speeds for Casper are 10-17 miles per hour and 50-60 miles per hour, respectively.

The local topography strongly influences micrometeorological conditions at the site. The dilution of airborne contaminants resulting from normal operating releases is determined largely by small-scale turbulence in the local area in combination with the prevailing wind.

Data on background levels of airborne pollutants in the vicinity of the mill are lacking. However, because of the lack of population, industry, and other pollution sources, combined with the good ventilation characteristics of the Wyoming atmosphere, the present air quality is considered to be good. The sparseness of the vegetative cover may result in large amounts of suspended particulate material during periods of high wind speeds.

Several nonradioactive vapors and gases, including kerosene and sulfur dioxide, are released to the atmosphere during ore processing. Minor amounts of oxides of nitrogen, ozone, and ammonia may be released. Water vapors and combustion products, mainly carbon dioxide, are released during concentrate drying operations. Emissions are maintained in compliance with the Wyoming Ambient Air Quality Standards.

SURFACE CONTAMINATION

Airborne particulate emissions from the ore storage piles and the ore crushing and grinding operations are controlled by maintaining the ore at its natural moisture content of 8 to 12 percent. Dust from the tailings, roads, and mine spoil piles is controlled by sprinkling as necessary.

The concentrate drying and packaging stack exhausts air, downstream of the stack scrubber, which contains uranium dust, thorium-230, and radium-226. Release of radon-222 from the concentrate stack is negligible.

UCC has never had any excursions from the ponds, nor have any tailings been removed from the site. There has been no neutralization of solutions before going to ponds.

At present, there is about 4 gallons per minute of seepage collected in three sumps around the inoperative tailings piles which is pumped back to the ponds. The maximum seepage was about 20 gallons per minute when the ponds were being utilized. There are seven piezometric wells plus several monitoring wells around the piles. Also, air samples are taken periodically.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

UCC will be required to conduct decommissioning and reclamation activities at the millsite in accordance with conditions of its NRC source materials license. UCC entered a surety agreement with Seaboard Surety, in the amount of $3,947,000, to satisfy an NRC license condition providing that decommissioning and tailings stabilization will be accomplished.

In accordance with Section 202 of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), standards for uranium tailings stabilization have been promulgated by NRC, effective November 1981 (45 CFR, p. 65521). They are to be consistent with standards of general applicability yet to be issued by EPA under UMTRCA. These final NRC rules are being challenged by the American Mining Congress and others.

UCC contracted with D'Appolonia Consulting Engineers, Inc., for investigation and evaluation of a number of alternative reclamation schemes. From the numerous options available, a preferred reclamation plan and an alternative reclamation plan have been chosen by UCC and submitted to the NRC and to the Wyoming Department of Environmental Quality (DEQ).

The preferred reclamation plan uses slopes of five units horizontal to one unit vertical, accomplished by cut-and-fill regrading. The area would then be covered with about 10 feet of material made up of approximately 6 inches of compacted clay, 5 feet of overburden, 4-1/2 feet of stockpiled spoils, and 10 inches of rock. This plan was selected because it will have long-term stability, it should require minimal maintenance and monitoring, and it will reduce radiation emanation to less than 2 picocuries per square meter per second above background. Although the rock proposed to be used is high in radioactivity, its use may be acceptable since much of the rock outcrop in the Gas Hills is high in radioactivity.

The alternative reclamation plan provides for slopes of ten units horizontal to one unit vertical, also accomplished by cut-and-fill regrading. The area would then be covered with about 10 feet of material made up of approximately 6 inches of compacted clay, 5 feet of overburden, 4 feet of stockpile spoils, and 6 inches of topsoil. Then the slopes would be revegetated. This plan will reduce radon emanation to less than 2 picocuries per square meter per second above background.

NRC's uranium mill licensing regulations provide for long-term surveillance and for a $250,000 payment to be made by the operator to the state or Federal Government prior to license termination to cover ongoing cost of long-term surveillance. As yet, UCC has not made this payment; it would prefer a bond.

UCC has estimated the total costs in 1981 dollars to reclaim the above-grade inoperative tailings piles under the preferred plan at $8.4 million, and under the alternative plan at $9.4 million. The author of this report estimated 29.4 percent of the cost to be attributable to the AEC sales as explained in Table 2.

UCC has also estimated reclamation costs based on the tailings pile as it existed at the end of 1970 when the AEC contract was terminated. The cost to grade the slope to ten units horizontal to one unit vertical and to place 10 feet of protective cover was estimated at $3.84 million (1981 dollars). At the end of 1970, this tailings pile contained 2,463,000 tons of tailings, a portion of which could be attributed to production of uranium for sale to the AEC. UCC suggests that 87.7 percent of the cost be attributed to the AEC sales. The author of this report has estimated 85 percent to be attributable to the Government sales. The method of derivation is explained in the third footnote of Table 2.

DISCUSSION OF PROPOSED COST-SHARING PLANS

It was pointed out to UCC's representatives that one of the cost-sharing options being considered was to use a simple ratio of (a) tonnage of tailings resulting from production for sales to the AEC to (b) total tonnage of tailings at the time of stabilization. UCC's representatives were asked to comment on this option, substitute options, or what items should be included in decommissioning and stabilization; they did not have any comments at that time.

PERTINENT AEC CONTRACT PROVISIONS

AEC first purchased U_3O_8 in concentrate produced in UCC's Gas Hills mill, under Contract No. AT(05-1)-745, from Globe Mining Company (GMC), a wholly owned subsidiary of UCC. This contract had an effective date (date of signing) of May 12, 1959, and a termination date of December 31, 1966 (plus an opportunity to deliver final concentrate until February 2, 1967). Under the provisions of the contract, GMC agreed, among other things, to construct and operate the mill and deliver the product, U_3O_8 in concentrate, to the AEC at Grand Junction, Colorado. AEC agreed, among other things, to purchase a certain maximum pounds of U_3O_8 in concentrate. A price was negotiated which prevailed from start-up through March 31, 1962. Beginning April 1, 1962, the price became a flat $8 per pound of U_3O_8 in concentrate.

The negotiated price had (1) a base price, and (2) additional price increments to provide for amortization of (a) mill start-up expense, and (b) maximum fixed capital investment based on a 5-year mill amortization period.

The negotiated base price provided for (1) Circular 5, Revised, ore value, (2) $0.06 per ton-mile for ore haulage, (3) negotiated mill operating costs, and (4) a negotiated mill profit.

The estimated mill operating costs provided for all phases of mill operation including tailings disposal costs for (1) operating and maintenance labor, (2) operating and maintenance supplies, (3) neutralization chemicals, and (4) utilities.

Several modifications were made to the contract, including Modification No. 2 which provided for an extension of the contract term to December 31, 1970, with final deliveries by February 5, 1971.

Modification No. 2 provided for "stretching out" deliveries of U_3O_8 in concentrate to the AEC by UCC. The principal provisions dealt with (1) "stretching out" deliveries between January 1, 1963, and December 31, 1966, to the 6-year period January 1, 1963, through December 31, 1968, (2) adding an additional quantity of U_3O_8 in concentrate to the contract, equal to the amount "stretched out," to be purchased by AEC during 1969 and 1970, and (3) price in 1969 and 1970 to be based on 85 percent of allowable unit costs experienced by UCC at the Gas Hills mill during the period January 1, 1963, through December 31, 1968, attributable to uranium plus $1.60 per pound U_3O_8 in concentrate.

REFERENCES

"Annual Mine/Mill Production Summaries from 1971 Through December 1981," by the Grand Junction Office of the AEC, ERDA, and DOE.

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"The Extractive Metallurgy of Uranium," Robert C. Merritt, Colorado School of Mines Research Institute, assigned to the General Manager of the U.S. Atomic Energy Commission, 1971.

"Final Environmental Statement Related to Operation of Gas Hills Uranium Project," Union Carbide Corporation, Division of Waste Management, Office of Nuclear Material Safety and Safeguards, U. S. Nuclear Regulatory Commission, July 1980.

Letter from Earl W. Shortridge, Business Manager, UCC, to Gilman C. Ritter, Director, Mining Division, BFEC, enclosing information about the Gas Hills facility.

Production Data Books, a compilation of uranium production data in the Western United States for the period 1948 through 1970, by the Grand Junction Office of the U.S. Atomic Energy Commission.

Section 213 Public Law 96-540, December 17, 1980.

FIGURES

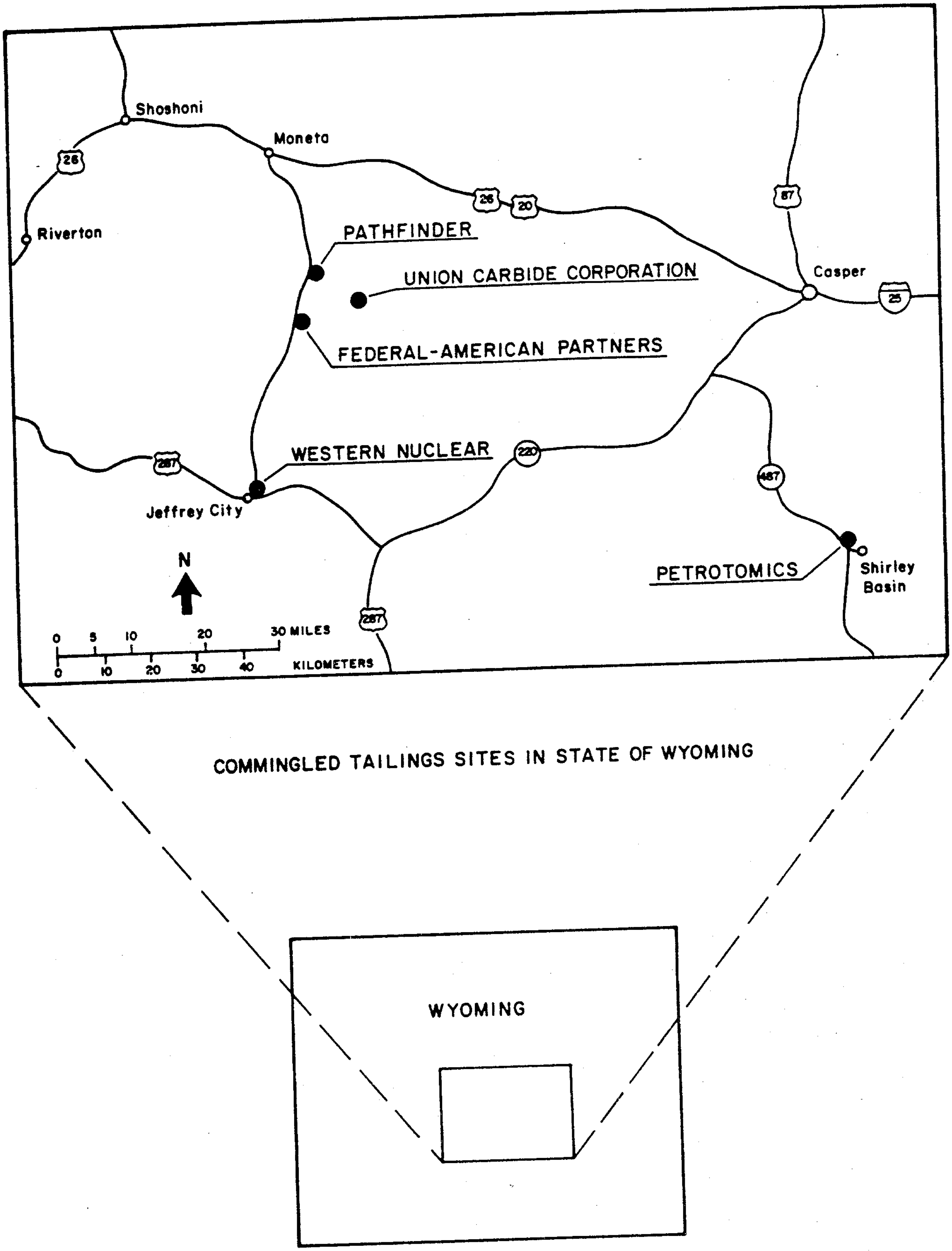

Figure 1. Location Map: Union Carbide Corporation, Gas Hills, Wyoming

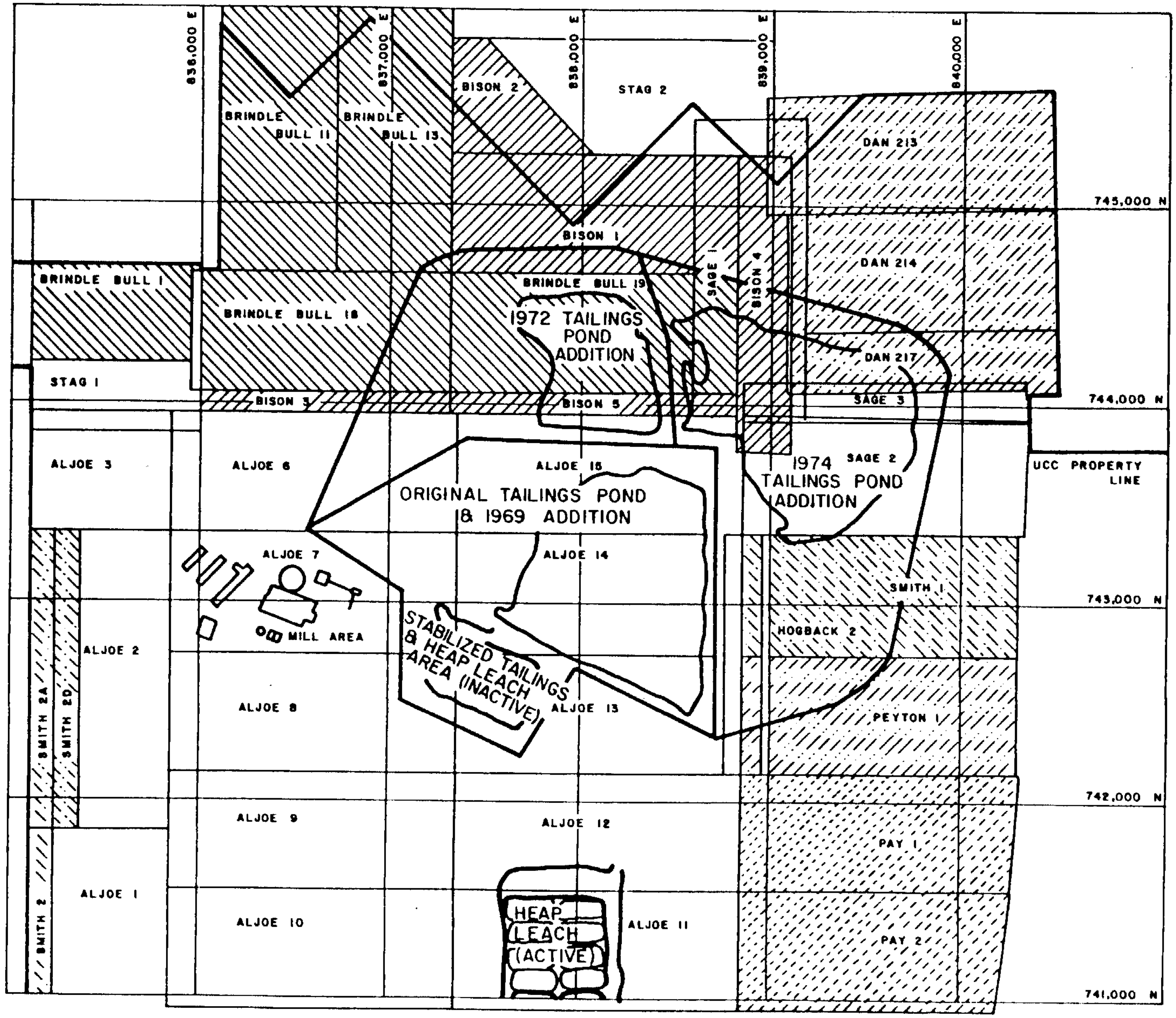

Figure 5. Relationship of Location of Inoperative Tailings Piles to Unpatented Lode Claims on Federal Lands

SITE REPORT: WESTERN NUCLEAR, INC.
Split Rock, Wyoming

INTRODUCTION

This report establishes the amount and condition of tailings located at Western Nuclear Incorporated's (WNI) millsite at Split Rock, Wyoming, and at four satellite operations that provided semirefined uranium products to the Split Rock mill for further processing. Because of commingling of tailings, the report provides a split between (1) those tailings attributable to the production of uranium concentrate sold to the United States for defense purposes, and (2) those tailings attributable to production of uranium concentrate for sale in the commercial market.

This report provides summaries of information and analyses of data obtained from WNI, Department of Energy (DOE) records, and from numerous professional papers, books, reports, memoranda, letters, and telephone calls pertinent to the report. The Nuclear Regulatory Commission's (NRC) final environmental statement for the Split Rock mill was relied on heavily.

BACKGROUND AND HISTORY

OWNERSHIP

Western Nuclear, Inc., a wholly owned subsidiary of Phelps Dodge Corporation (PD), owns the Split Rock uranium mill and tailings pile located approximately 2 miles north of Jeffrey City, Wyoming. The mill was constructed and originally operated by Lost Creek Oil and Uranium Company. The name of the company was changed to Western Nuclear Corporation in 1957 and to Western Nuclear, Inc. (WNI), in 1959. PD acquired WNI in May 1971. WNI and the State of Wyoming own the land on which the tailings pile is located.

WNI also owns and operates an ion-exchange (IX) plant in the Green Mountains, approximately 10-12 miles south of the Split Rock mill, in which natural uranium is recovered from mine water in the form of a slurry of precipitated magnesium diuranate. This intermediate product is then shipped to the Split Rock mill for final processing.

Under its NRC license conditions, WNI has reclamation responsibility for three sites in the Gas Hills area, approximately 15-20 miles north of the Split Rock mill. At two of these sites, Bull Rush and Day-Loma, low-grade ore was leached to produce an intermediate product for final processing in the Split Rock mill. These two heap-leach sites are now owned by Federal-American Partners and Energy Fuels Exploration Company, respectively. The depleted ore pads and sumps remain at the Bull Rush site. Reclamation is under way at the Day-Loma site.

WNI formerly owned and operated an ion-exchange (IX) facility at the Rox mine, the third site in the Gas Hills area that WNI has reclamation responsibility for under its NRC license. As at the Green Mountain IX plant, uranium was extracted from mine waters. The loaded resin was transported to the Split Rock mill for stripping. All buildings and equipment have been removed to the Split Rock millsite although the concrete pad on which the IX columns were located remains at the Gas Hills site. Reclamation is under way at the Rox site.

WNI also formerly owned and operated the Spook upgrader which was located in Converse County, Wyoming, approximately 165 miles north-northwest of the Split Rock mill. Acid-cured pellets of ore were percolation heap leached in vats at the Spook upgrader. This plant site is included in the inactive millsite tailings program and is mentioned here only because the upgrader's product was shipped to the Split Rock mill for further processing and because U_3O_8 in concentrate derived from the upgrader's product was sold to the AEC.

PRODUCTION HISTORY

Mill operations began in September 1957 and continued through June 19, 1981, when production was limited to that resulting from final processing of uranium in slurry produced at the Green Mountain IX plant. Future mill operations are indefinite, but preliminary plans call for a restart of the mill in 1984 at a portion of capacity in order to fill presently existing sales contracts.

AEC purchased uranium produced in the plant from start-up until June 30, 1969, when the purchase contract was terminated. A total of 14,935,569.44 pounds of U_3O_8 in concentrate was purchased by the AEC at an average price of about $8.11 per pound. Shortly before termination of the AEC contract, WNI began producing U_3O_8 in concentrate for sale in the commercial market. According to DOE records, the total production of U_3O_8 in concentrate from start-up through June 30, 1969, was 15,818,793 pounds from (1) 3,544,542 tons of ore containing 16,509,646 pounds of U_3O_8, (2) 88,597 pounds of U_3O_8 contained in heap-leach product, and (3) 348,095 pounds of U_3O_8 contained in precipitated slurry product from the Spook upgrader. WNI records indicate that production for this period came from (1) 3,544,092 tons of ore containing 16,389,006 pounds of U_3O_8, (2) 208,899 pounds of U_3O_8 contained in heap-leach product, and (3) 348,577 pounds of U_3O_8 contained in precipitated slurry product from the Spook upgrader.

From July 1, 1969, through December 31, 1981, WNI continued to produce uranium for the commercial market. According to DOE records, during this period 10,538,202 pounds of U_3O_8 in concentrate were produced from (1) 4,151,974 tons of ore containing 11,164,955 pounds of U_3O_8, and (2) 216,672 pounds of U_3O_8 contained in the precipitated slurry produced in the Green Mountain IX plant. WNI records indicate that production for this period came from (1) 4,159,969 tons of ore containing 11,059,968 pounds of U_3O_8, (2) 130,119 pounds of U_3O_8 contained in precipitated slurry produced in the Green Mountain IX plant, (3) 195,640 pounds of U_3O_8 from the Day-Loma, Bull Rush, and Rox sites, and (4) 68,478 pounds of U_3O_8 from mill recycle water, Spokane test and Dalco, Texas.

PROCESS DESCRIPTIONS AND MAJOR CHANGES

Split Rock Mill

Construction of the original Split Rock mill started in October 1956 and the plant was placed in operation in June 1957. Nominal mill capacity was 400 tons per day of 0.20 percent U_3O_8 ore. The process initially used included (1) receiving, crushing, sampling, and stockpiling, (2) grinding and classifying, (3) acid leaching, (4) sand-slime separation, (5) basket resin-in-pulp (RIP) ion-exchange, (6) eluate clarification, (7) precipitation, (8) thickening, filtering, drying, and packaging, and (9) tailings sampling and disposal.

Prior to the start-up of the mill, the AEC operated at the site a temporary buying and sampling station for various small producers in the area, and stockpiled the ore for future processing by WNI.

Expansion of plant capacity in 1959 required additions in the grinding, leaching, sand-slime separation, and RIP circuits. An ore dryer was installed to prevent freezing of wet ore in the fine ore bins. Continuous precipitation and product drying processes were installed in place of the original batch processes. Capacity was increased from 400 to 1000 tons of ore per day. In the spring of 1965, a solvent extraction circuit was added in order to realize the appreciable savings in reagent costs by the use of the "Eluex" process.

Late in 1966 the basket RIP circuit was removed and replaced with a continuous countercurrent RIP process. In addition, the entire product filtration circuit, consisting of vacuum drum filters with all related equipment, was removed and replaced with a continuous centrifuge.

A molybdenum circuit was installed in 1966 but was never used. Intention was to clean up the eluate to prevent contamination of the final uranium product. Later, a carbon circuit was installed to treat the pregnant strip solution but it was never "turned on."

In 1962 a sulfuric acid plant was constructed not only to provide the requirements of the Split Rock mill but also for sale to other users of acid in the area.

Early in 1974 WNI shut down the mill until late in 1975 to replace the ore drying, crushing, storage, and grinding equipment with a cascade mill and pulp storage tanks. The new nominal capacity of 1700 tons of ore per day was attained in 1977.

Heap Leaching Facilities

The Bull Rush heap-leach operations consisted of preparation of the leach pads, circulation of sulfuric acid solutions to attain the required buildup of uranium, and hauling the pregnant solutions to the Split Rock mill for final processing.

The original Day-Loma heap-leach process was similar to that described for the Bull Rush site, except that in 1966 a solvent extraction circuit was added in which sodium carbonate was used as a stripping agent. The pregnant strip solution was then transferred to the Split Rock mill for final processing.

Ion-Exchange Plants

The Green Mountain IX plant recovers natural uranium from mine waters in the Crook's Gap area. Drainage water from several mines is collected in a pond, then pumped through columns where the uranium is loaded onto resin. The uranium is stripped from the resin with sodium chloride - sodium bicarbonate solutions and precipitated as magnesium diuranate. The precipitated slurry is then shipped to the Split Rock mill for final processing.

The Rox mine IX plant process was similar to that described for the Green Mountain IX plant except that the loaded resin was shipped to the Split Rock mill for stripping and as a result no chemicals were used in the process at the Rox mine site.

SITE DETAIL

LOCATION

Figure 1 shows the geographic relationship of the Split Rock millsite to the State of Wyoming. The mill is located approximately 2 miles north of Jeffrey City, Wyoming, and about 40 miles southeast of Riverton, Wyoming, the nearest population center. The millsite and the tailings pile currently occupy about 70 and 167 acres, respectively.

Figure 1 also shows the locations of the Bull Rush and Day-Loma heap-leach and the Green Mountain IX sites. The heap-leach sites are in the Gas Hills area which is north of the Split Rock mill. A county road provides access to the area. The Day-Loma site is about 15 miles from the Split Rock mill and the Bull Rush site about 20 miles. The Green Mountain IX plant is in the Crook's Gap area about 12 miles south of the Split Rock mill.

TOPOGRAPHY

Figure 2 shows the topography of the Split Rock millsite. It is located in the midst of granite peaks of the Granite Mountains, in the west-central portion of the Sweetwater Plateau. The plateau is a southeasterly ridge of high elevations which essentially separates the Wind River and the Great Divide Basins of the Wyoming Basin physiographic province. The surface of the plateau has gently rolling alpine meadows interrupted by moderate-to-high-relief granite peaks. Regionally, elevations range from about 6200 feet near the Sweetwater River to over 9000 feet in the high peaks of the Green Mountains south of the mill.

The gently meandering Sweetwater River has cut a winding path through some of the exhumed Precambrian granite. The mill is situated at an elevation of about 6350 feet, at the base of a saddle between two adjacent tracts of granite peaks about 1 mile south of the Sweetwater River.

The Green Mountain IX plant is located south of the mill in the same physiographic province. It is near Sheep Mountain Peak (elevation 7900 feet) and about 1 mile east of Crook's Creek.

Figure 3 shows hydrologic features in the vicinity of the Split Rock mill and the Green Mountain IX plant.

CURRENT CONDITION OF TAILINGS

Figures 4 and 5 are photographs, taken in October 1981, showing the Split Rock mill commingled tailings pile. Figure 4 provides two views of the solid and liquid tailings contained within the pile, while Figure 5 depicts two views of the tailings embankment. The tailings are impounded in a natural depression in the form of a draw about 1000 feet east to the southeast of the mill. As mentioned earlier, the tailings cover about 167 acres.

Tailings have been windblown beyond the immediate retention area. WNI is testing certain chemicals which could be sprayed onto the problem areas. Tests conducted thus far have been promising.

QUANTITIES

Table 1 shows a year-by-year breakdown of (1) ore and other sources of uranium fed to process at WNI's Split Rock mill, (2) U_3O_8 in concentrate produced, (3) U_3O_8 in concentrate sold to the AEC, and (4) price at which uranium was sold to the AEC, as shown in AEC's records. Subtotals are shown for the period covered by AEC purchases (start-up-June 30, 1969) and the period covered exclusively by commercial sales (July 1, 1969-December 31, 1981).

Table 2 shows the amount of tailings resulting from the production of uranium for sale to the AEC as of (1) termination of the AEC contract (June 30, 1969), (2) latest date for which production data are available (December 31, 1981), and (3) forecast date of final shutdown of plant for decommissioning and stabilization (January 1, 2004). Presently, the tailings resulting from the production of uranium for sale to the AEC represent about 43 percent of the total tailings at the Split Rock millsite. At the estimated time of mill decommissioning and tailings stabilization, it might amount to about 19 percent of the total.

Table 3 shows a period-by-period breakdown of (1) ore and other materials fed to process and (2) uranium concentrate produced at WNI's Split Rock mill, as provided by WNI. The tabulation is similar to Table 1 except that it shows a more comprehensive breakdown of "other uranium" materials fed to process. Also, note that the quantities of U_3O_8 in ore shown from fiscal year 1967 through calendar year 1971 are somewhat different on Table 3 than are shown on Table 1. These differences are largely accounted for by U_3O_8 contained in other than ore fed to the mill, so that when one compares total U_3O_8 fed

Table 1. Amount of Ore and Other Uranium Material Fed to Process, Uranium Produced, Uranium Sold to AEC, and Prices at Which Uranium Was Sold to AEC at Western Nuclear, Inc., Split Rock, Wyoming (As Shown in AEC Records)

	Time Period	Fed To Process						Conc. Produced, U_3O_8 (lbs.)	Sold to AEC, U_3O_8 (lbs.)	Price, \$/lb. U_3O_8
		Ore			Ore Conc.[a] (lbs. U_3O_8)	Other[b] (lbs. U_3O_8)	Total U_3O_8 (lbs.)			
		Tons	% U_3O_8	U_3O_8 (lbs.)						
1.	Start-up - June 30, 1958	236,716	0.196	938,983	-	-	928,983	796,296	775,735.46	10.45
2.	July 1, 1958-June 30, 1959	221,178	0.200	886,801	-	-	886,801	822,033	849,228.63	10.10
3.	July 1, 1959-June 30, 1960	342,665	0.240	1,646,841	-	-	1,646,841	1,495,864	1,490,087.86	7.72
4.	July 1, 1960-June 30, 1961	403,503	0.237	1,914,845	-	-	1,914,845	1,752,005	1,616,340.00	7.78
5.	July 1, 1961-June 30, 1962	365,182	0.235	1,717,943	30,979	776	1,749,698	1,598,503	1,674,108.00	7.82
6.	July 1, 1962-June 30, 1963	322,709	0.256	1,650,108	170,556	25,569	1,846,233	1,738,474	1,541,413.89	7.99
7.	July 1, 1963-June 30, 1964	206,036	0.279	1,148,407	100,823	22,550	1,271,780	1,233,040	1,217,236.00	8.00
8.	July 1, 1964-June 30, 1965	260,463	0.214	1,112,536	45,737	19,458	1,177,731	1,098,712	1,217,236.00	8.00
9.	July 1, 1965-June 30, 1966	261,759	0.276	1,444,573	-	20,244	1,464,817	1,414,548	1,217,344.71	8.00
10.	July 1, 1966-June 30, 1967	239,206	0.224	1,070,563	-	-	1,070,563	1,017,638	1,150,770.11	8.00
11.	July 1, 1967-June 30, 1968	399,304	0.226	1,808,781	-	-	1,808,781	1,753,252	1,075,620.73	8.00
12.	July 1, 1968-June 30, 1969	285,821	0.206	1,179,265	-	-	1,179,265	1,098,428	1,110,448.04	7.12
	SUBTOTALS	3,544,542	0.233	16,509,646	348,095	88,597	16,946,338	15,818,793	14,935,569.44	8.11
13.	July 1, 1969-June 30, 1970	309,768	0.226	1,400,347	-	-	1,400,347	1,329,091		
14.	July 1, 1970-Dec. 31, 1970	149,972	0.210	631,009	-	-	631,009	572,760		
15.	Jan. 1, 1971-Dec. 31, 1971	213,659	0.218	933,417	-	24,635	958,052	916,064		
16.	Jan. 1, 1972-Dec. 31, 1972	203,392	0.248	1,010,427	-	10,992	1,021,419	1,000,859		
17.	Jan. 1, 1973-Dec. 31, 1973	211,465	0.217	917,725	-	4,030	921,755	865,806		
18.	Jan. 1, 1974-Dec. 31, 1974	79,189	0.210	332,955	-	46,404	379,359	368,755		
19.	Jan. 1, 1975-Dec. 31, 1975	24,968	0.228	113,838	-	27,724	141,562	105,431		
20.	Jan. 1, 1976-Dec. 31, 1976	405,089	0.116	940,845	-	5,792	946,637	817,645		
21.	Jan. 1, 1977-Dec. 31, 1977	570,686	0.090	1,022,572	-	10,815	1,033,387	900,079		
22.	Jan. 1, 1978-Dec. 31, 1978	596,599	0.094	1,118,657	-	17,250	1,135,907	1,048,632		
23.	Jan. 1, 1979-Dec. 31, 1979	594,564	0.103	1,230,072	-	17,270	1,247,342	1,136,086		
24.	Jan. 1, 1980-Dec. 31, 1980	586,102	0.099	1,157,912	-	27,544	1,185,456	1,113,662		
25.	Jan. 1, 1981-Dec. 31, 1981	206,521	0.086	355,179	-	24,216	379,395	363,332		
	SUBTOTALS	4,151,974	0.135	11,164,955	-	216,672	11,381,627	10,538,202		
	GRAND TOTAL	7,696,516	0.180	27,674,601	348,095	305,269	28,327,965	26,356,995		

[a]Spook upgrader product sent to Jeffrey City and processing completed in the Split Rock Mill.

[b]Heap-leach, ion-exchange, and water-recycle products produced in Gas Hills and Green Mountain areas and sent to Jeffrey City for final processing.

Table 2. Amount of Tailings and Size of Pile at Western Nuclear's Split Rock Mill at Various Dates

	6/30/69	12/31/81	1/1/04[a]
Tailings (short tons)			
AEC Contract[b]	3,346,636	3,346,636	3,346,636
Commercial Sales	197,906	4,349,880	14,051,974
Totals	3,544,542	7,696,516	17,398,610
AEC Contract, Percent of Total	94	43	19
Area Covered (acres)	83[c]	167[c]	256[c]
Average Pile Height (feet)	25[c]	28[c]	

[a]DOE forecast of possible date for decommissioning and tailings stabilization; based on 20 years of operation after a January 1, 1984, start-up date, an operating rate of 1500 tons per day, and 330 days of operation per year.

[b]Based on proportion of pounds of U_3O_8 in concentrate sold to AEC and total pounds of U_3O_8 in concentrate produced through June 30, 1969, i.e.,

$$3{,}544{,}542 \text{ Tons of Ore Fed to Process} \times \frac{14{,}935{,}569 \text{ Lbs. } U_3O_8 \text{ Sold to AEC}}{15{,}818{,}793 \text{ Lbs. } U_3O_8 \text{ Produced}}$$

[c]Estimated by WNI.

Table 3. Amount of Ore and Other Material Fed to Process and Uranium Produced at Western Nuclear, Inc.'s Split Rock, Wyoming, Mill (As Provided by Western Nuclear, Inc., In Attachments I and II to February 23, 1982, Letter to DOE)

Time Period	Fed to Process										
	Ore			Other Than Ore, U_3O_8 (lbs.)							Concentrate Produced, U_3O_8 (lbs.)
					Heap Leach		Ion-Exchange				
	Tons	%U_3O_8	U_3O_8 (lbs.)	Ore Conc.[a]	Day-Loma	Bull Rush	Rox	Green Mt.	Misc.[b]	Total, U_3O_8 (lbs.)	
1. Start-up-Dec. 31, 1957	83,729	0.200	335,079	-	-	-	-	-	-	335,079	259,314
2. Jan. 1, 1958-Dec. 31, 1958	293,021	0.199	1,165,380	-	-	-	-	-	-	1,165,380	1,059,576
3. Jan. 1, 1959-June 30, 1959	81,144	0.194	315,325	-	-	-	-	-	-	315,325	299,439
4. July 1, 1959-June 30, 1960	342,665	0.240	1,646,841	-	-	-	-	-	-	1,646,841	1,495,864
5. July 1, 1960-June 30, 1961	403,503	0.237	1,914,845	-	-	-	-	-	-	1,914,845	1,752,005
6. July 1, 1961-June 30, 1962	365,182	0.235	1,717,942	30,980	776	-	-	-	-	1,749,698	1,598,503
7. July 1, 1962-June 30, 1963	322,709	0.256	1,650,250	170,556	24,473	1,096	-	-	-	1,846,375	1,738,474
8. July 1, 1963-June 30, 1964	206,036	0.279	1,148,408	100,823	-	22,550	-	-	-	1,271,781	1,233,040
9. July 1, 1964-June 30, 1965	260,463	0.214	1,112,537	45,737	-	19,458	-	-	-	1,177,732	1,098,712
10. July 1, 1965-June 30, 1966	261,759	0.276	1,444,573	481	-	19,763	-	-	-	1,464,817	1,414,548
11. July 1, 1966-June 30, 1967	239,206	0.223	1,068,593	-	881	1,089	-	-	-	1,070,563	1,017,638
12. July 1, 1967-June 30, 1968	399,304	0.220	1,757,203	-	51,578	-	-	-	-	1,808,781	1,753,252
13. July 1, 1968-June 30, 1969	285,821	0.195	1,112,029	-	67,235	-	-	-	-	1,179,264	1,098,428
SUBTOTALS	3,544,542	0.231	16,389,005	348,577	144,943	63,956	-	-	-	16,946,481	15,818,793
14. July 1, 1969-June 30, 1970	309,769	0.217	1,347,250	-	53,097	-	-	-	-	1,400,347	1,329,091
15. July 1, 1970-Apr. 30, 1971	239,523	0.191	914,516	-	46,314	-	3,592	-	-	964,422	902,938
16. Apr. 30, 1971-Dec. 31, 1971	124,107	0.242	601,255	-	23,012	-	361	-	-	624,628	585,886
17. Jan. 1, 1972-Dec. 31, 1972	203,389	0.248	1,010,427	-	5,526	-	142	5,324	11,028	1,032,447	1,011,888
18. Jan. 1, 1973-Dec. 31, 1973	211,463	0.217	917,727	-	-	-	-	4,030	-	921,757	865,807
19. Jan. 1, 1974-Dec. 31, 1974	81,662	0.204	332,955	-	-	-	-	12,078	34,326	379,359	368,754
20. Jan. 1, 1975-Dec. 31, 1975	24,969	0.228	113,838	-	-	-	-	10,934	16,790	141,562	105,431
21. Jan. 1, 1976-Dec. 31, 1976	405,090	0.116	940,842	-	-	-	-	5,793	-	946,635	813,728
22. Jan. 1, 1977-Dec. 31, 1977	570,681	0.090	1,022,573	-	-	-	-	10,817	-	1,033,390	903,993
23. Jan. 1, 1978-Dec. 31, 1978	596,629	0.093	1,115,425	-	-	-	-	17,249	-	1,132,674	1,048,635
24. Jan. 1, 1979-Dec. 31, 1979	595,062	0.103	1,230,073	-	-	-	-	17,270	-	1,247,343	1,136,086
25. Jan. 1, 1980-Dec. 31, 1980	586,104	0.099	1,157,909	-	-	-	-	26,568	2,175	1,186,652	1,113,662
26. Jan. 1, 1981-Dec. 31, 1981	206,521	0.086	355,178	-	-	-	-	20,056	4,159	379,393	356,550
SUBTOTALS	4,154,969	0.133	11,059,968	-	127,949	-	4,095	130,119	68,478	11,390,609	10,542,449
GRAND TOTALS	7,699,511	0.178	27,448,973	348,577	272,892	63,956	4,095	130,119	68,478	28,337,090	26,361,242

[a]Spook upgrader product sent to Jeffrey City and processing completed in the Split Rock Mill.

[b]Uranium contained in recycled mill water, Spokane test material, and purchased material from DALCO (Texas).

to the mill as shown by Tables 1 and 3, differences are very small, especially for the period during which AEC purchased uranium from WNI (start-up-June 30, 1969). In fact, ore tonnages (3,544,542) and U_3O_8 in concentrate produced (15,818,793) are exactly the same in the two tables. This means that the data shown in Table 2 would be the same whether calculated from Table 1 or Table 3.

In its report to the American Mining Congress Subcommittee, WNI shows that the Bull Rush heap-leach pad contains between 100,000 and 200,000 tons of low-grade uranium material, and the Day-Loma heap-leach pads contain between 200,000 and 400,000 tons of low-grade uranium-bearing material. We were unable to obtain from WNI single-number estimates for each of the two heap-leach sites. Using the above-cited ranges and uranium production data shown in Table 3, the appropriate split of heap-leach tailings is shown in Table 4.

TAILINGS MANAGEMENT HISTORY

The tailings were pumped to the pile in the form of a slurry and spigotting created a beach of tailings by depositing coarse tailings near the slurry discharge locations and progressively finer particles at a distance from these points. A slurry water pond was created at the upstream end of the tailings beach. By periodically moving the discharge location from place to place along the western edge of the pond, a fan-type embankment was created with higher elevations of coarse sands near the discharge, thereby providing the retention system for the slurry water pond.

There have been two tailings release incidents, one in 1971 and the other in 1977. Neither incident resulted in any effluent discharged off-site. In March 1971, a tailings release resulted from a break in the slurry pipeline causing a dike failure that allowed tailings to flow to a natural basin adjacent to the tailings pond and within the WNI property boundary.

In April 1977, "lack of timely filling operations" contributed to the over-topping of the retention embankment by solutions with no release of material to a restricted area. As a result of this second incident, WNI contracted with D'Appolonia Consulting Engineers, Inc., to develop a plan for tailings disposal for the remaining operating life of the Split Rock mill. Three reports were prepared. Report 1 presents the engineering and construction aspects of the tailings management plan. Report 2 presents the studies, investigations, and conclusions regarding the abandonment plans and the stabilization of exposed tailings against wind erosion. Volume 1 of Report 3 presents the environmental effects of tailings disposal practiced in 1977 and practices proposed for the future. Volume 2 of Report 3 presents itemized responses to specific NRC questions.

ENVIRONMENTAL CONSIDERATIONS

DEMOGRAPHY

The area surrounding the Split Rock millsite is sparsely populated. The largest population center within 50 miles of the millsite is Riverton, 40 miles to the northwest, with a 1977 estimated population of about 10,000. Jeffrey City, 2 miles to the south of the mill and about 10 miles north of the Green Mountain IX plant, has an estimated 1976 population of 2000.

Table 4. Amount of Tailings at the Day-Loma and Bull Rush Heap-Leach Sites at Various Dates

	6/30/69		12/31/82	
	Day-Loma	Bull Rush	Day-Loma	Bull Rush
Heap-Leach Tails (short tons)				
AEC Contract	(100,000-200,000)[a]	(94,000-188,000)[a]	(100,000-200,000)	(94,000-188,000)
Commercial Sales	(6,000- 12,000)	(6,000- 12,000)	(100,000-200,000)	(6,000- 12,000)
Totals	(106,000-212,000)[b]	(100,000-200,000)[b]	(200,000-400,000)	(100,000-200,000)
AEC Contract, Percent of Total	94	94	50	94

[a]Based on proportion of pounds of U_3O_8 in concentrate sold to AEC and total pounds of U_3O_8 in concentrate produced through June 30, 1969, i.e.,

Day-Loma (106,000-212,000) x $\frac{14,935,569}{15,818,793}$ = (100,000-200,000) tons

Bull Rush (100,000-200,000) x $\frac{14,935,569}{15,888,903}$ = (94,000-188,000) tons.

[b]Based on proportion of U_3O_8 in heap-leach product produced during the period (start-up-6/30/69) to total U_3O_8 in heap-leach product from the specific heap-leach site, i.e.,

Day-Loma (200,000-400,000) x $\frac{144,943}{272,892}$ = (106,000-212,000) tons

Bull Rush (100,000-200,000) x $\frac{63,956}{63,956}$ = (100,000-200,000) tons.

WATER

Split Rock Mill

The Sweetwater River, which flows approximately 1 mile north of the Split Rock millsite, is the major surface drainage in the Sweetwater Plateau. It is a tributary of the North Platte River, has its origins in the Wind River Mountains (west of the millsite), and flows generally from west to east. According to U.S. Geological Survey data covering a 37-year published period (1937-1974), the average, maximum, and minimum flows were 126, 4290, and 0.5 cubic feet per second, respectively. The Sweetwater River is utilized for irrigation and stock watering through direct pumping or diversion ditches.

As the mill neither utilizes surface water nor discharges effluent into surface drainageways, there is no direct impact on water use or water supply. However, the possibility exists that seepage from the tailings pond could make its way to off-site surface waters.

Ground water occurs on the Sweetwater Plateau under both water-table (unconfined) and artesian (confined) conditions. Alluvial deposits are not utilized as a source of irrigation water in the region as surface water supplies are adequate.

Abundant amounts of ground water exist in the Sweetwater Valley aquifer in the region of the Split Rock mill and are used for industrial, sanitary, and stock watering purposes. In view of the large flows from individual wells, no impact on current ground-water use is expected.

Seepage from the tailings pond at the Split Rock mill is substantial and contains a number of elements and compounds originating with the ore and the milling process. Some of these chemicals are water-soluble and potentially toxic. Most radioactive contaminants will usually be absorbed within 10 to 30 feet of the tailings pond bottom. WNI indicates that radioactive contamination of ground water has not progressed beyond the site boundaries. Attempts to predict future migration of these contaminants indicate that over a 30-year period migration would be negligible. The migration of arsenic seems to be appreciable when compared to the migration of radionuclides during the first 10 years of migration, but analyses indicate that the concentration of arsenic at the ion front will be well below drinking-water quality standards and will stop about 1500 feet within the site boundary.

WNI representatives indicated that the State of Wyoming is concerned about the quality of the off-site ground water because of the high content of sulfate and total dissolved solids. WNI has 30 monitor wells and an emergency pumpback system. WNI does not know how the State of Wyoming will administer water quality regulations as they apply to industrial operations.

Figure 3 shows hydrological features in the vicinity of the Split Rock mill and Green Mountain IX plant.

Ion-Exchange Plants

At the Green Mountain ion-exchange plant site, the uranium-barren water that is not returned to the mines for use in the ion-exchange operation is treated with barium chloride to remove the radium and then sent to a primary settling pond where most of the contaminants settle out before the water enters the secondary pond. After leaving the secondary settling pond, the treated water is discharged into a natural drainage channel before it reaches Crook's Creek. The NRC staff expects the radiologic impact of the discharged water on the environment to be negligible.

As mentioned earlier, the Rox mine ion-exchange facility is not operational, and all buildings and equipment, except for a concrete pad, have been removed to the Split Rock millsite. When the facility was operational, the loaded resin was hauled to the Split Rock millsite for stripping, and the uranium-depleted mine water was discharged into the natural drainage without treatment. No visit was made to the Rox mine site.

AIR

Split Rock Mill

The principal impact on air quality at the Split Rock millsite could be the suspended particulate matter, mainly fugitive dust removed from the tailings pile and carried by the prevailing winds. As indicated earlier, there was evidence of windblown tailings beyond the immediate retention area at the time of the millsite visit. Also, as indicated earlier, WNI is testing certain chemicals which could be sprayed onto the problem areas.

Other sources of particulates are fugitive dust from the drying and packaging operations and the ore storage pads. The topography restricts the off-site movement of particulates. Emissions of particulates to the air during uranium concentrate drying and packaging are controlled by scrubbers with high efficiencies. Negligible releases of radon occur during the drying and packaging process. Because the moisture content of the ore ranges from 8 to 14 percent, wind-generated dust from the ore pads has not been, nor is it expected to be, a problem when the mill starts operating again.

Gaseous effluents from plant operations include SO_2, NO_2, sulfuric acid fumes, and kerosene fumes, which are not expected to affect the air quality because only small amounts are involved.

SURFACE CONTAMINATION

Split Rock Mill

The greatest quantity of waste generated by the mill is the barren tailings which contain essentially the entire mass of ore processed. These tailings have been deposited in an area east to the southeast of the plant since the beginning of mill operations in 1958 in the form of a water slurry. As indicated earlier, there have been two tailings release incidents, neither of which resulted in any discharges off-site.

Heap Leaching Operations

Heap leaching at the Day-Loma and Bull Rush sites is inoperative at the present time. Attempts were made to observe the conditions at the heap-leach sites on October 29, 1981, and again in the afternoon of December 17, 1981. On neither occasion was it possible to locate the heap-leach sites.

NRC's final environmental statement for the Split Rock mill, dated February 1980, indicated that WNI will be required to clean up abandoned equipment and to cover the abandoned holding ponds at the Bull Rush, Day-Loma, and Rox sites.

Ion-Exchange Plants

As indicated earlier, barium chloride is used at the Green Mountain ion-exchange plant site to treat the uranium-barren water that is not returned to the mines. WNI personnel said that the primary pond, where most of the contaminants settle out, will be dredged when necessary during plant operations and at the end of operations when the site is restored. The dredged material will be hauled to the Split Rock mill tailings pond for final disposal.

As no chemicals were used at the Rox mine ion-exchange plant, no precipitated contaminants were generated.

DISCUSSION OF VIABLE STABILIZATION OPTIONS

WNI will be required to conduct decommissioning and reclamation activities at the millsite in accordance with conditions of its NRC source materials license. WNI entered a surety agreement with Federal Insurance Company, assessed by the State of Wyoming, to satisfy an NRC license condition providing that decommissioning and tailings stabilization will be accomplished.

In accordance with Section 202 of the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), standards of uranium tailings stabilization have been promulgated by NRC, effective November 1981 (45 CFR, p. 65521). They are to be consistent with standards of general applicability yet to be issued by EPA under UMTRCA. These final NRC rules are being challenged by the American Mining Congress and others, including WNI.

NRC requires a minimum payment of $250,000 (1980 dollars), or more if NRC deems necessary, to the General Treasury of the United States or to an appropriate state agency prior to termination of the mill license to cover the cost of long-term surveillance. It is NRC's position that the $250,000 can be a part of the bonding requirements.

WNI has submitted to both the State of Wyoming and to NRC a final reclamation plan. After removal of ancillary mill facilities, WNI proposes to remove and dispose in the tailings pond any soil material that contains radioactivity above 20 microroentgens per hour, above background, 1 meter above the ground level. Postmilling contours of the mill and office areas will approximate premiling contours. At "abandonment," the tailings pile will be allowed to dry, then will be contoured into the existing terrain. Riprap and gravel will be used on the steeper portions of the main drainageways. All other portions of the regraded drainage will have gentle slopes. WNI proposes to cap the tailings with 6 inches of clay, 6 feet of subsoil, and 6 inches of gravel topping for control of erosion.

All disturbed areas would be reseeded with suitable species, mulched, and fertilized. Fencing will be maintained until reclamation has proven to be successful.

WNI has estimated the cost of the proposed material handling and reclamation (stabilization) to be approximately $10.6 million. WNI estimates a cost of about $14.2 million if NRC enforces its requirement of 3 meters (10 feet) of cover. The $3.6-million increase would provide for an additional 4 1/2 feet of subsoil, over and above the 6 feet included in the base case.

Although WNI has not used the phrase "mill decommissioning," within the reclamation costs is $1.9 million for the cost of "mill abandonment."

The reclamation plan which has been submitted to the Wyoming Department of Environmental Quality and to the NRC is bonded in the amount of $10,586,000. The reclamation plan has been approved by the State of Wyoming, but as of February 23, 1982, WNI has not received approval from NRC.

Cleanup and stabilization costs for both the Bull Rush and the Day-Loma heap-leach sites are estimated by WNI at $1,500,000. WNI indicates that a high percentage of the estimated costs are attributable to material produced pursuant to the AEC contracts.

DISCUSSION OF PROPOSED COST-SHARING PLANS

It was pointed out to the WNI representatives that one of the cost-sharing options being considered was to use a simple ratio of (a) tonnage of tailings resulting from production for sales to the AEC to (b) the total tonnage of tailings at the time of stabilization, and multiplying this ratio with the allowable costs for decommissioning and stabilization. WNI representatives were asked to comment on this option, substitute options, or what items should be included in decommissioning and stabilization. They did not have any comments at the time of the site visit.

On October 29, 1981, WNI representatives provided the attached listing of "Cost Items and Sequence To Be Considered in DOE's Commingled Tailings Report to Congress." The list includes not only decommissioning and reclamation of the Split Rock site (which this report covers), but also (1) environmental costs, state and Federal, during the period of mill operations, (2) environmental costs during the period of shutdown of the mill to the point of final reclamation and decommissioning (allowing pond to dry), and (3) costs involved with perpetual care (long-term surveillance). Later, WNI informed us that it endorses the outline "Cost Factors of Interest to Owners," presented at the meeting held in Grand Junction, January 21, 1982.

PERTINENT AEC CONTRACT PROVISIONS

CONTRACT NO. AT(05-1)-709

AEC first purchased U_3O_8 in concentrate produced in the Split Rock mill from Lost Creek Oil and Uranium Company (Lost Creek) under Contract No. AT(05-1)-709. This contract had an effective date (date of signing) of August 10, 1956, and a termination date of March 31, 1962 (plus 3 months to "clean out" the circuit). Under the provisions of this contract, Lost Creek agreed, among other things, to construct and operate the mill and deliver the product, U_3O_8 in concentrate, to the AEC at Grand Junction, Colorado. AEC agreed, among other things, to purchase a maximum of 2.9 million pounds of U_3O_8 in concentrate at a base price that varied with the grade of ore fed to the mill and adjusted for changes in the Wholesale Price Index for all commodities. In addition to the base price, additional increments provided for (1) amortization of fixed (a) maximum capital cost, (b) mill start-up expense, and (c) precontract process development; and (2) \$0.06 per ton-mile for ore haulage over 35 miles up to a maximum of 100 miles. The negotiated base price provided for (1) Circular 5, revised, ore value, (2) \$0.06 per ton-mile for ore haulage, up to 35 miles, (3) mill operating costs, and (4) a negotiated milling profit.

A review of supporting AEC files shows that the estimated mill operating costs provided for all phases of mill operation including tailings disposal costs for (1) operating and maintenance labor, (2) operating and maintenance supplies, (3) neutralization chemicals, and (4) utilities. Of course, there was no contractual requirement that expenditures be made for such items by the contractor.

The AEC provided a Certificate of Necessity which permitted the contractor to utilize rapid amortization of mill construction costs.

The name of the corporation was changed to Western Nuclear Corporation on March 25, 1957.

Four modifications were made to Contract No. AT(05-1)-709, including Modifications 3 and 4 which provided for its early termination in order to simultaneously enter into a new agreement.

CONTRACT NO. AT(05-1)-765

Contract No. AT(05-1)-765, which replaced Contract No. AT(05-1)-709, had an effective date of July 1, 1959, and a termination date of December 31, 1966 (plus an opportunity to deliver final concentrate until February 2, 1967). Among other things, this new contract provided for (1) extension in the contract term from April 1, 1962, through December 31, 1966, (2) a fixed price of \$8 per pound U_3O_8 in concentrate after March 31, 1962, (3) increase in yearly purchases of U_3O_8 in concentrate by the AEC, (4) an expansion in the mill capacity, and (5) uranium sales to licensed buyers upon written permission and AEC terms.

A new base price was negotiated that did not vary with grade of ore fed to the mill. Additional amortization cost covering the mill expansion was negotiated based on a 5-year amortization period. The mill amortization, per pound of U_3O_8 in concentrate, was reduced because of the increase in purchases by AEC through March 31, 1962.

Several modifications were made to Contract No. AT(05-1)-765, including Modification No. 4 which provided for an extension of the contract term to December 31, 1970, with final deliveries by February 5, 1971.

Modification No. 4 provided for "stretching out" sales of U_3O_8 in concentrate to the AEC by WNI. The principal provision dealt with (1) "stretching out" deliveries between January 1, 1963, through December 1968; (2) adding an additional quantity of U_3O_8 in concentrate to the contract, equal to the amount "stretched out," to be purchased by AEC during 1969 and 1970; and (3) price in 1969 and 1970 to be based on 85 percent of allowable unit costs experienced by WNI during the period January 1, 1963, through December 31, 1968, plus \$1.60 per pound U_3O_8 in concentrate.

The last modification provided for early termination date of June 30, 1969.

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FIGURES

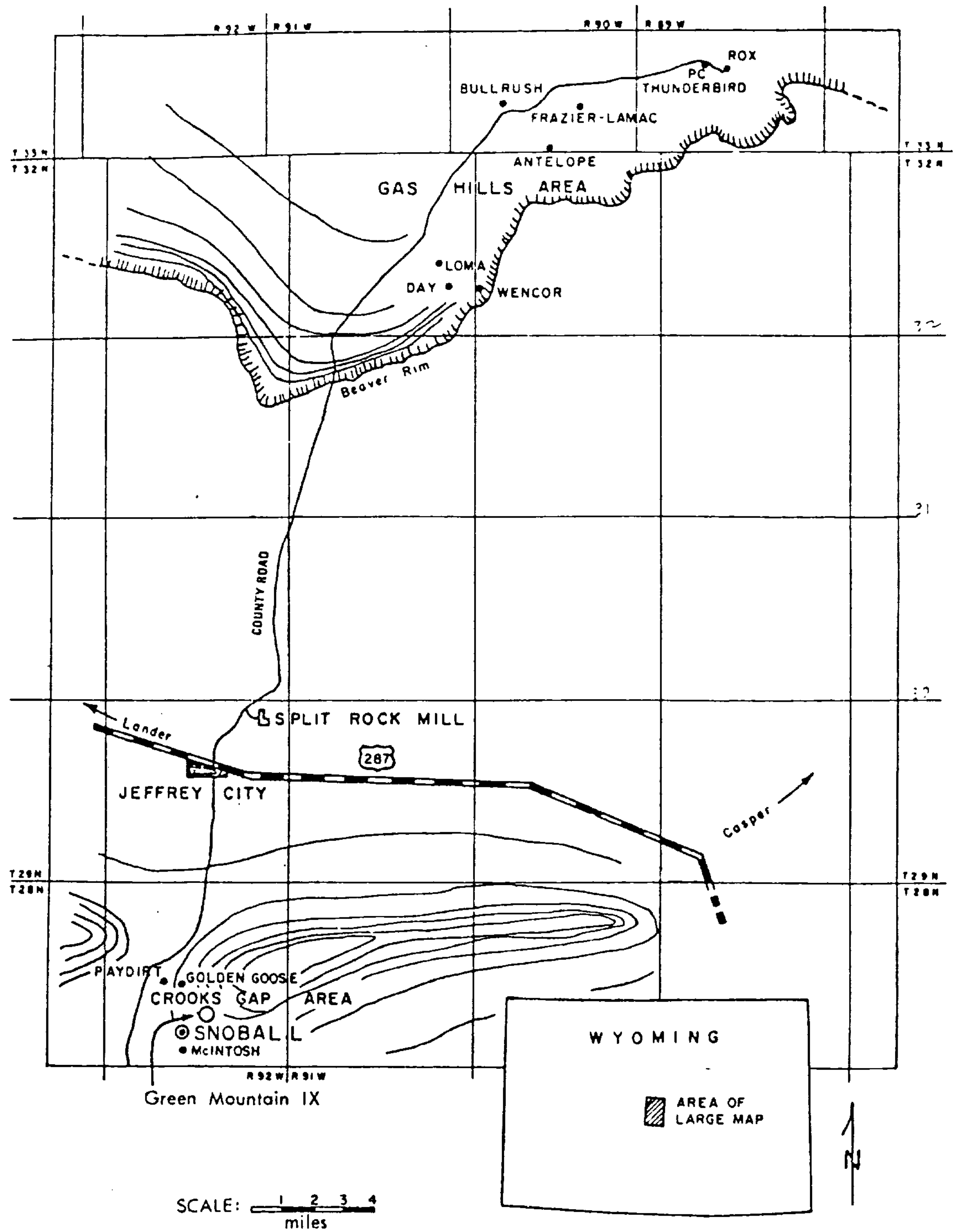

Figure 1. Geographic Relationship of the Split Rock Mill and Green Mountain IX Plant to Jeffrey City and to the Gas Hills and Crook's Gap Uranium Deposits

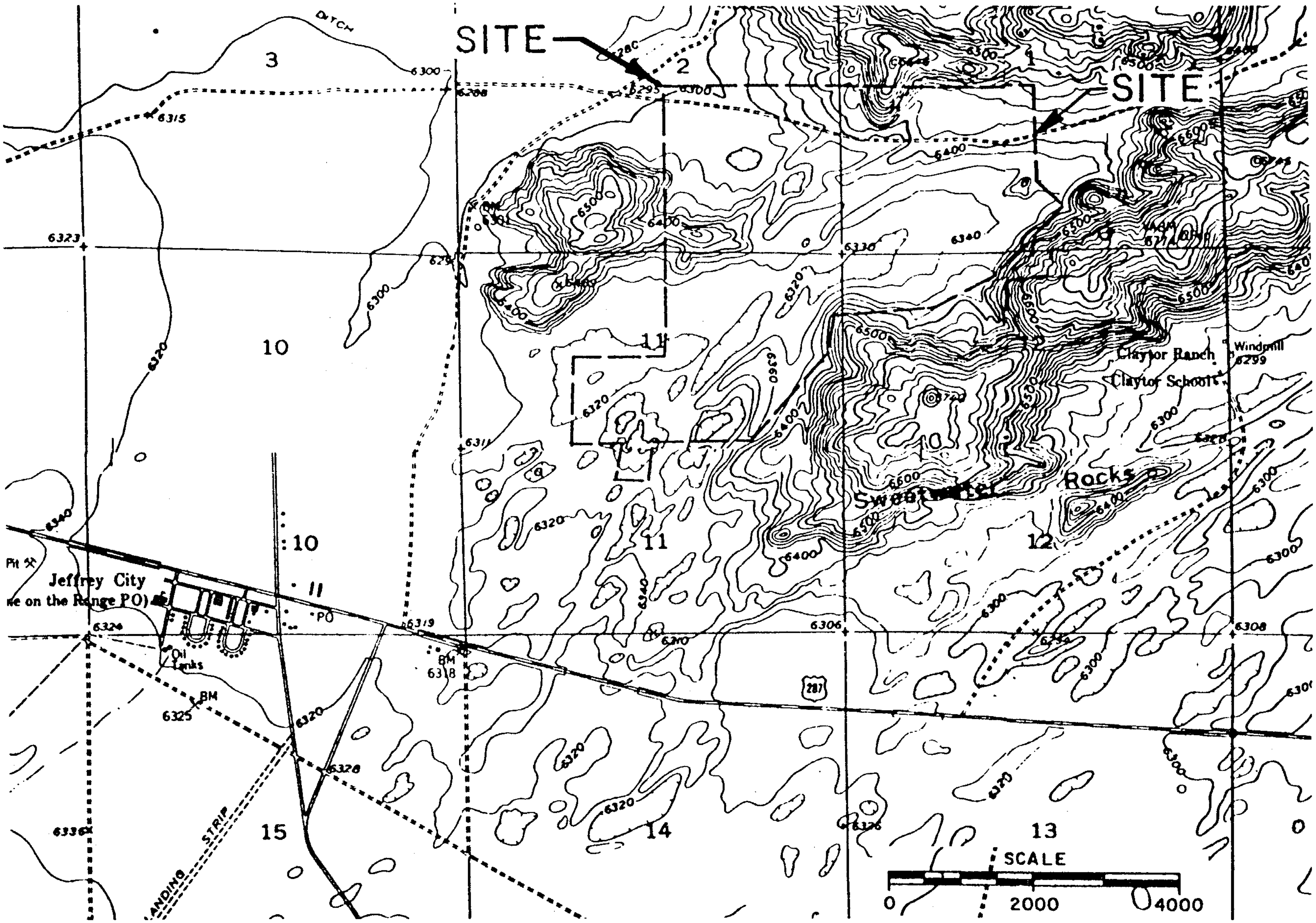

Figure 2. Topography of the Split Rock Millsite (from D'Appolonia, Report 3, Vol. 1, Fig. 2-3)

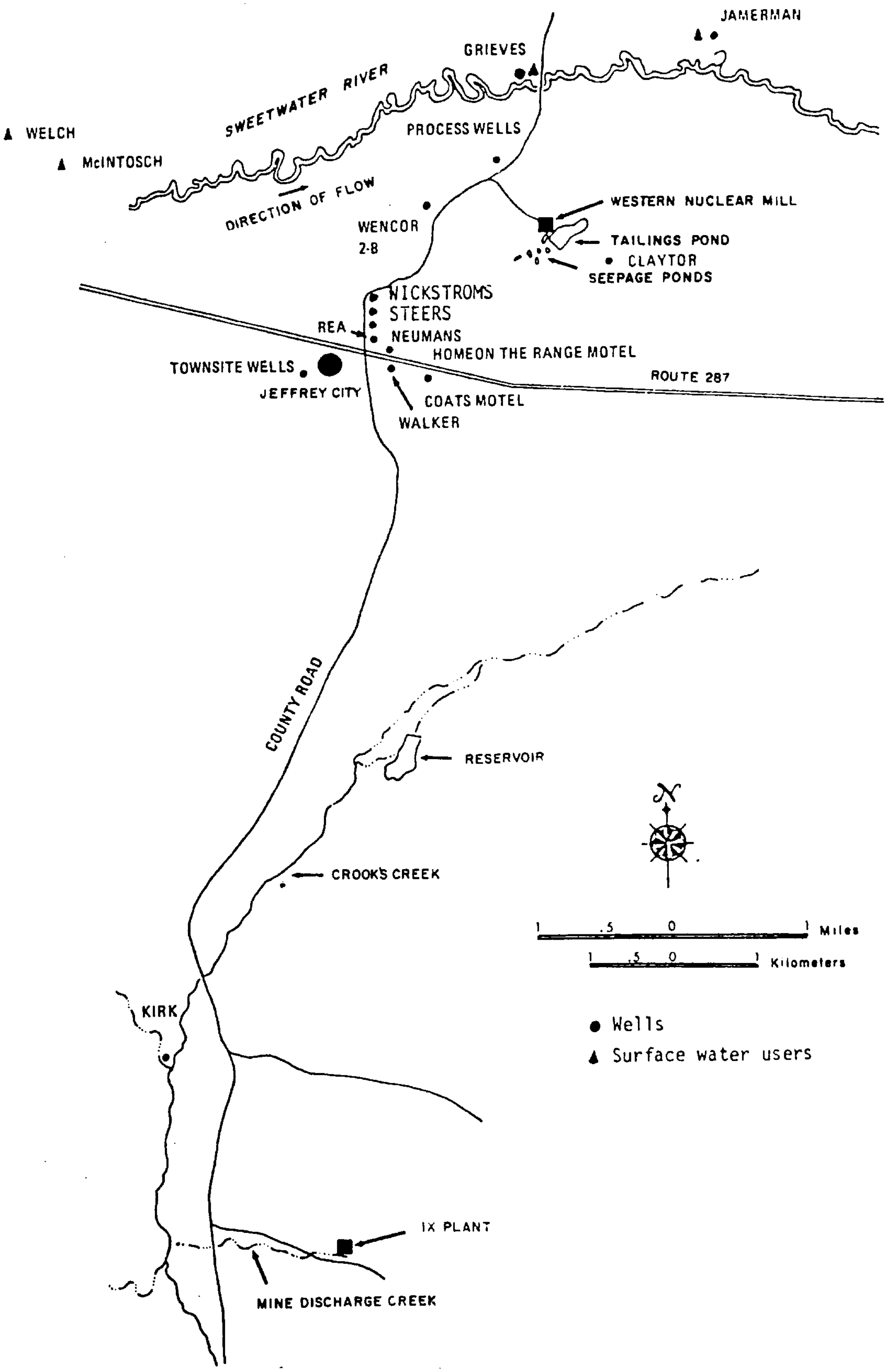

Figure 3. Hydrologic Features in the Vicinity of the Split Rock Mill and Green Mountain IX Plant, Including Area Well Locations

APPENDIX B: VICINITY PROPERTIES

The tailings identified at locations in Nucla and Naturita are closer to the inactive tailings at Naturita, a more likely source than the Uravan tailings.

None of the surveys indicated significant contamination or clean-up problems in the northern New Mexico communities of Grants, Bluewater, and Milan. No tailings were ever removed from the Anaconda and Homestake sites, according to company officials. The New Mexico Environmental Improvement Division has indicated that cleanup of the few places identified has taken place and that no trouble spots exist at present.

Sixty-one locations with anomalous gamma-radiation levels were reported in the Edgemont, South Dakota, area. Surveys conducted by the EPA and State of South Dakota personnel showed 44 properties classified as tailings locations. Of these, 25 were tailings under or within 10 feet of a habitable structure. The tailings at 16 of the 25 locations appeared to be from windblown migration from the pile. At 8 of the 25 locations, tailings had been hauled onto the property for various uses. At one location, tailings were used under a basement floor slab and as fill around basement walls in the yard.

With support of the NRC, the Battelle Pacific Northwest Laboratories (BPNL) commenced in October 1980 a detailed assessment of the required remedial action. Objectives of the BPNL program are to survey the Edgemont area using radiological analysis equipment and to provide the necessary engineering assessments for remedial action. BPNL has been measuring gamma-radiation levels, radon daughter concentrations, and radium content of soils to locate properties where mill tailings might have been used. As these locations are identified, plans, specifications, and cost estimates for remedial action are developed. As of January 1982, 29 properties had been selected for development of remedial action plans. Through January 1982, BPNL had identified 45 properties having residual radioactive materials, but in many cases the materials are at some distance from habitable structures. To date, the BPNL surveys have cost in excess of $500,000 and total estimated costs through the architectural-engineering phase are about $1 million. Total costs may be as much as $2 million, depending upon the number of properties requiring remedial action and the decontamination criteria used.

The EPA and State of Utah surveys showed 15 properties in the Moab area classified as tailings locations. Uranium ore specimens or truck spillage was found at 76 locations. There has been no estimate of the remedial action cost to remove tailings from under, around, or near the 15 EPA-identified tailings locations, but the problem does not appear serious because of the low gamma-radiation readings. Unless cleanup is more complicated than would be indicated by EPA data, it probably could be accomplished for less than $100,000. Atlas officials are dubious that EPA-identified properties are actually tailings locations because no tailings were ever released from the Moab, Utah, millsite.

Structures numbering 391 were surveyed in the communities of Ford, Creston, Little Falls, Long Lake, Loon Lake, Reardan, and Springdale near the Dawn, Washington, millsite. Sixteen low-level anomalies were reported. Follow-up surveys of each anomaly by EPA and State of Washington personnel revealed that the anomalies were due to the presence of brick and/or concrete in the structures. No locations with tailings were found. Hence, off-site remedial action, other than retrieval of windblown tailings, will not be required at this site.

The EPA survey of 4 central Wyoming communities showed 26 properties classified as tailings locations and 96 as nontailings locations, as follows:

Town	Tailings Locations	Nontailings Locations
Hudson	0	7
Jeffrey City	13	15
Lander	4	74
Shirley Basin	9	0
Totals	26	96

There has been no estimate of the remedial action cost to remove tailings from under, around, or near the 26 EPA-identified tailings locations. None of the millsite owners in Wyoming report removal of tailings from the premises.

In areas where multiple sources of mill tailings exist, such as central Wyoming, and the source of tailings which result in the contamination of a vicinity property cannot be determined, the remedial action could be cost-shared totally by the Federal and state governments, or by the Federal Government and all vicinity mill owners. Where the source of the tailings can be attributed to a particular mill, the remedial action cost could be shared by the Government and mill owner on the same basis as the shared stabilization costs.

APPENDIX C: BENEFITS OF STABILIZATION

BENEFITS OF STABILIZATION

What threat do unstabilized tailings pose to the public? Are the benefits to be gained from stabilization programs substantial enough to justify the expense of the programs? Answers to these questions are of such length as to be beyond the scope of this study; however, a brief discussion of the comparative health risks of uranium tailings and the cost of minimizing those risks is warranted. The establishment of reasonable tailings stabilization requirements is in the best interest of all concerned: Government, private industry, and taxpayers.

The major quantifiable health concern related to mill tailings is that of radiation exposure. For the purposes of determining health risks from tailings, it has been assumed that all ionizing radiation may be carcinogenic, that there is no "safe" dose, and that the probability of health effects in the form of increased cancer deaths will increase linearly with increasing doses of radiation. Regulations and standards distinguish between two types of exposure: that received by the lungs from radon decay products and whole body exposure to nonradon sources. Of these two, radon is the greater concern.

EPA has made risk assessments for radon decay products based on epidemiological studies of uranium miners. While these studies contain the best available data on which to base such assessments, there are several flaws in their use as a solitary data source. For example, the number of uranium miners studied is very small in comparison to the population of the general public over which the results have been extrapolated. Uranium miners are also exposed to much higher levels of radiation than those levels found near mill tailings. Other differences include demographic factors of miners as a group such as sex, age, and cigarette smoking. Therefore, the EPA has conceded that projections made from this information should only be "estimates, not predictions" (U.S. EPA, 1980).

Independent studies have demonstrated that EPA risk estimates may be too high by as much as a factor of 10 (Evans, 1981). In addition, a study by Richard J. Hickey and others has produced a negative correlation between background radiation and mortality rate for cancer, rather than a positive linear correlation. The study specifically noted that while both background radon and total external radiation level around UMTRAP inactive tailings sites are significantly higher than the respective U.S. averages, rates for respiratory cancers and total cancers are significantly lower around these sites than the U.S. averages (Hickey et al., 1981).

Ionizing radiation emanates from the soil and rocks in man's environment and is present in the atmosphere. It has been estimated that the radon emanation from 1 square mile of bare land is approximately equal to that from 1 acre of tailings (Evans, 1981). Background radiation varies with natural conditions such as moisture content, vegetative cover, and fluctuations in barometric pressure. Evans asserts that "the level of radon-decay-product exposure at distances greater than 1/4 to 1/2 mile (from a tailings pile) is a minute fraction of the range of fluctuation of the natural background of the area" (Evans, 1981).

To gain perspective on the magnitude of background radon emissions compared to radon released from all uranium mill tailings, one can compare the potential annual premature cancer deaths resulting from both sources. NRC has estimated deaths attributed to postoperational releases from tailings stabilized under the "base case" to be less than three per year. This rate contrasts sharply with the annual rate from nontailings sources, for example: 30 expected deaths from radon released by soil tillage, 86 deaths from evapotranspiration from soil surfaces and vegetation, 1152 deaths from radon emanating from natural soils, and 1594 deaths from radon released from building interiors (NRC, 1980). Other estimates indicate that the indoor radon-induced cancer rate may be six times greater (Rosenbaum, 1982).

Despite the large amount of radiation produced naturally in the environment, standards and regulations have been imposed which further reduce the comparatively minute amount of radiation emitted by uranium mill tailings. Benefits derived from stabilization of mill tailings under applicable standards and regulations have been expressed in several ways. The EPA estimated that implementation of standards for inactive uranium processing sites would prevent 2000 premature lung cancer deaths over the next 1000 years (U.S. EPA, 1980). EPA did not, however, compare this average of two deaths per year to the annual U.S. death rate from lung cancer of 92,000.

EPA also estimated that 170 to 240 deaths from cancer would occur over 100 years from radon emitted from the 25 inactive sites if they are not covered to reduce radon emissions. Limiting radon emissions from inactive tailings piles to 100 pCi/m^2-sec would reduce radon-induced deaths by 78 percent. Further decreasing emissions by a factor of 50 to the proposed 2 pCi/m^2-sec level, thereby increasing cover requirements and the cost of stabilization by $80,000 to $120,000 an acre (DOE, 1981), would result in the reduction of cancer deaths by at most 0.6 death per year over the 100 pCi/m^2-sec standard.

EPA has differentiated between deaths occurring within 50 miles of the sites (130-150) and deaths occurring more than 50 miles from the sites (40-90). However, because radon emanation from the inactive tailings piles is statistically indistinguishable from background levels at distances greater than one-half mile from the piles, most of the projected health effects will be borne by the immediately surrounding population. Because current dispersion models have overestimated the actual field measurements, the extent to which radon from tailings affects the national, regional, or even the entire community in which the pile is located is debatable (Evans, 1981). The proximity of significant populations to the commingled tailings sites is shown in Table C-1.

Table C-1. Distance from Millsite to Nearest Significant Population

Mill/Location	Town	Distance from Millsite (miles)	Approximate Population
Cotter, Colo.	Canon City	2	13,000
	Total Pop. within 5-mi. Radius (incl. Canon City)		16,000
UCC, Colo.	Uravan	-	500
	Nucla	15	1,000
	Naturita	17	800
Anaconda, N. Mex.	Anaconda Housing	-	200
	Bluewater	1.5	300
	Milan	8	2,600
	Grants	11	10,500
Homestake, N. Mex.	Broadwater & Murray Acres Subdivisions	1	200
	Anaconda Housing	5	250
	Milan	7	2,600
	Bluewater	7	300
	Grants	10	10,500
Kerr-McGee, N. Mex.	San Mateo	12	250
	Prewitt	12	160
	Anaconda Housing	13	250
	Bluewater	14	300
	Milan	16	2,600
	Grants	17	10,500
TVA, S. Dak.	Edgemont Area (incl. Cottonwood & Dudley)	-	1,635
Atlas, Utah	Moab	2	5,340
	Total Pop. within 10-mi. Radius (incl. Moab)		6,300
Dawn, Wash.	Largely Rural; Total Pop. within 1-mi. Radius		90
	Total Pop. within 6-mi. Radius		465
Fed.-Amer. Part., Wyo.	Largely Rural; Total Pop. within 5-mi. Radius		90
	Jeffrey City	25	1,000
	Shoshoni	35	880
	Riverton	40	10,000
	Casper	65	50,000
Pathfinder, Wyo.	Largely Rural; Total Pop. within 5-mi. Radius		100
	Jeffrey City	30	1,000
	Shoshoni	40	880
	Riverton	50	10,000
	Casper	50	50,000

Table C-1. Distance from Millsite (continued)

Mill/Location	Town	Distance from Millsite (miles)	Approximate Population
Petrotomics, Wyo.	Petrotomics Housing	2	700
	Casper	48	50,000
UCC, Wyo.	Shoshoni	42	880
	Riverton	50	10,000
	Casper	60	50,000
WNI, Wyo.	Jeffrey City	2	1,000
	Riverton	40	10,000

Cost-benefit analyses of remedial action options have been prepared for the inactive sites by Ford, Bacon & Davis Utah, Inc. Table C-2 lists the cost of each cancer death avoided after 25 and 100 years by stabilization in place under EPA standards, the least costly method considered, for seven sites. Costs range from $250,000 per health effect at Salt Lake City, to more than $52 million per health effect at the Tuba City site.

Table C-2. Costs and Benefits of Stabilization In Place for Certain UMTRAP Sites

Site	Cost per Health Effect Avoided (millions of dollars)	
	After 25 Years	After 100 Years
Salt Lake City, Utah	0.96	0.26
Grand Junction, Colorado	1.7	0.34
Rifle, Colorado	>5.7	>1.1
Durango, Colorado	8.2	1.9
Shiprock, New Mexico	11.2	3.4
Gunnison, Colorado	>22.3	>4.2
Tuba City, Arizona	>52.0	>12.0

The NRC did not perform an incremental cost-benefit analysis of environmental and health effects in the development of their uranium milling regulations because of the highly subjective nature of all factors involved. The maximum emission level for radon was set at 2 pCi/m^2-sec under the objective of "returning sites to conditions near those of surrounding environs." From 100 pCi/m^2-sec to virtually zero radon emanation was given as a possible range from which to determine a standard for radon flux, if the value placed on averting a health risk was set between $10,000 and $10,000,000. By choosing the 2 pCi/m^2-sec level, a value closer to $10,000,000 was placed on the prevention of each cancer death.

In essence, the cost of tailings stabilization under current and proposed regulations and standards will be millions of dollars per cancer death avoided. Furthermore, total estimated tailings-related deaths are statistically insignificant compared to total cancer deaths in the United States. As the American Mining Congress has pointed out, a potential of 2 deaths per year over a 200,000,000 population is essentially an annual risk of 1 in 100,000,000. The NRC has compared such a risk to the risks posed by "a few puffs on a cigarette, a few sips of wine, driving the family car about 6 blocks, flying about 2 miles, canoeing for 3 seconds, or being a man aged 60 for 11 seconds" (NRC, 1981). The 1-in-100,000,000 risk may also be compared to other greater but "socially acceptable" risks such as bicycling (1 in 100,000), drinking 1 pint of milk per day (1 in 100,000), and air travel of one transcontinental flight per year (1 in 330,000) (Wilson, 1978).

The possibility of contamination of ground-water resources from chemicals such as selenium, molybdenum, and nitrates presents another potential environmental health effect from uranium mill tailings. The EPA standards for inactive sites dictate that, after stabilization, tailings may not cause pollutant levels in an underground drinking water source to "exceed specific contaminant levels," or to increase at all where background contamination already exceeds standards (U.S. EPA, 1980). Estimates of health risks from contaminated ground water were not made as was done for radiation exposure because of fundamental differences in the toxicologies of the possible pollutants. Effects of chemicals on human health vary with the substance encountered; the severity of effects varies with the dose. For example, symptoms associated with selenium toxicity vary with consumption of from 0.01 to 1.0 milligram of the chemical per kilogram of body weight (EPA, 1976) (Goyer and Mehlman, 1977). While chronic molybdenum toxicity has been observed following consumption of 10 to 15 milligrams per day, less pronounced symptoms occur from consumption of 0.5 to 1.5 milligrams of molybdenum per day (Chappell et al., 1979). For some chemicals, there is a threshold level below which the damage is reparable by the body. Water consumption among individuals is also variable. Because of the specificity of chemical effects and the site-specific nature of all ground-water problems, the potential for adverse health effects from ground-water contamination has not been as thoroughly documented as the more easily quantifiable radiation exposure data. Cost of ground-water cleanup is difficult to estimate.

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APPENDIX D: HISTORY OF THE AEC DOMESTIC URANIUM CONCENTRATE PROCUREMENT PROGRAM

HISTORY OF THE AEC DOMESTIC URANIUM CONCENTRATE PROCUREMENT PROGRAM

INTRODUCTION

Procurement of uranium concentrates by the Atomic Energy Commission (AEC) spanned the period from 1947 through 1970. During those years, in definable stages, the market for uranium concentrates changed from a monopsony with the Federal Government as the only buyer, to a completely commercial market with no Government purchases. From the viewpoint of the Government as a consumer, the foreseeable supply of uranium increased from desperately short of that which was required for defense needs, to adequate, to surplus. Procurement policies and contracting practices were adopted, implemented, and modified in response to the Government's changing needs and the perceived lack or adequacy of uranium supplies with which to meet them.

The AEC procurement policies and practices were not dictated solely by its defense needs, however. The agency was also guided by provisions of the Atomic Energy Acts of 1946 and 1954 which were designed to foster development and utilization of atomic energy for peaceful purposes. Therefore, procurement policies also reflected concern for fostering and maintaining a producing uranium industry which would be able to supply the nation's expected uranium requirements for private nuclear power development.

This synopsis will cite uranium procurement policies employed by the AEC to satisfy the dual objectives set forth above, and will briefly describe the mechanisms used to effectuate those policies.

THE BEGINNING SITUATION, 1947

On January 1, 1947, the Atomic Energy Commission (AEC), established by the Atomic Energy Act of 1946, assumed management of the Government uranium procurement program. Prior to that time, beginning in 1942, the program had been carried out by the Manhattan Engineer District, Corps of Engineers. By the beginning of 1947, that agency had purchased about 12,000 tons of U_3O_8 for use in developing atomic weapons. Only about 15 percent of that amount, obtained as a vanadium byproduct, was attributable to domestic production.

Five vanadium processing plants had operated on the Colorado Plateau during World War II, aided by a Government program offering incentive for vanadium production. That program was terminated in 1944, however, and by the end of 1946, only one plant was still operating, and only at half capacity. A total of 55 men were employed in the 15 vanadium-uranium mines operating on the Colorado Plateau, and uranium production was practically nill.* It was from this almost nonexistent resource base that the AEC launched its Domestic Uranium Procurement Program in 1947.

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*Address by Jesse C. Johnson, Manager, Raw Materials Operations, U.S. Atomic Energy Commission, at a meeting of the American Mining Congress, Salt Lake City, Utah, August 30, 1950.

SUMMARY OF THE PROCUREMENT PROGRAM

During the period 1947-1970, the AEC purchased uranium concentrate from private companies primarily for use in military weapons programs. Prior to April 1, 1962, the AEC also purchased uranium ores and guaranteed the prices to be paid by the milling companies for ores as an incentive to the uranium mining industry to provide feed for the processing mills. From a contracting standpoint, the pre-1962 period was characterized by guaranteed ore prices and individually negotiated concentrate prices.

On May 24, 1956, the AEC announced the establishment of a new domestic uranium procurement program for the period April 1, 1962, through December 31, 1966. The action was taken "in recognition of the need for a continuing Government market in order to maintain a high rate of exploration and development." The new program guaranteed a Government market for 500 tons U_3O_8 in concentrate per year from any one mining property or operation at a flat price of $8 per pound. Thus, in 1956, the stage was set for a continuing AEC concentrate procurement program after March 31, 1962, with an established price for concentrates rather than for ores.

By late 1957, dramatic increases in reported ore reserves and in milling capacity prompted an AEC announcement that "it no longer is in the interest of the Government to expand production of uranium concentrate."* Then, in November 1958, in order to prevent further expansion of production under its essentially unlimited purchase commitment, the AEC redefined its 1962-1966 procurement program by withdrawing portions of the program announced in May 1956. The Government stated it would buy, in the 1962-1966 period only, "appropriate quantities of concentrate derived from ore reserves developed prior to November 24, 1958, in reliance upon the May 24, 1956, announcement."† Other aspects of the program announced in 1956 were retained: The AEC would buy only concentrates; the U_3O_8 price would remain at $8 per pound; and ores would not be purchased nor ore prices guaranteed.

With the objective of fostering the development and utilization of atomic energy for peaceful purposes, the AEC announced in May 1958 that "domestic producers of uranium ores and concentrate may now make private sales of these materials to domestic and foreign buyers for peaceful uses of atomic energy."‡ All such sales would be subject to licensing by the AEC, and the release of uranium under contract to the AEC would be considered, subject to appropriate contract modifications. While this announcement removed the legal impediment to private sales of uranium concentrate, no such sales were actually made until 1966.

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*Remarks prepared by Jesse C. Johnson, Director, Division of Raw Material, U.S. Atomic Energy Commission, for delivery before the 4th Annual Conference of the Atomic Industrial Forum, New York, New York, October 28, 1957.

†Announcement dated November 21, 1958, and released November 24, 1958.

‡Public statement issued by the U.S. Atomic Energy Commission in Washington, D.C., May 8, 1958.

In 1962, it was apparent to the AEC that the private market for uranium concentrates would not be sufficient to sustain a viable domestic uranium industry by the end of 1966 when the AEC procurement program was scheduled to end. Thus, in November 1962, the AEC announced its "stretch-out" program for 1967 through 1970.* Under the program, the milling companies could voluntarily defer delivery of a portion of their 1963-1966 contract commitments until 1967 and 1968 in return for an AEC commitment to purchase, in 1969 and 1970, an additional amount of U_3O_8 equal to the quantity so deferred. The "stretch-out" program was the last of the major policy changes made in the AEC procurement program, although in January 1969, the AEC requested and accepted proposals for some further reductions in deliveries of concentrates in 1969 and 1970. The procurement program ended December 31, 1970.

URANIUM ORE PROCUREMENT

The ultimate procurement aim of the AEC was to purchase uranium in concentrates. Its first uranium procurement action was execution of a contract with Vanadium Corporation of America on May 28, 1947, for the delivery of concentrates from its mill at Naturita, Colorado. It was obvious that production of concentrates was directly dependent upon an assured supply of uranium ores, which in turn required a rapid expansion of exploration and mining efforts. To provide an incentive for those efforts, in April 1948, the AEC announced a domestic procurement program designed to stimulate prospecting and to build a domestic uranium mining industry. Private industry would be tasked with finding, mining, and processing uranium ores. The AEC would assist by making geologic surveys, furnishing free testing and assaying services, and, most important, guaranteeing a market for uranium ores.

The AEC ore market guarantee was promulgated by a series of Domestic Uranium Program Circulars, several of which were occasionally revised and extended.

Circular 1 (April 11, 1948) guaranteed for 10 years a minimum price for certain high-grade uranium ores. It expired April 11, 1958.

Circular 2 (April 11, 1948) offered a bonus of $10,000 for delivery of 20 short tons of uranium-bearing ores or mechanical concentrates assaying 20 percent or more U_3O_8 from any single mining location, lode, or placer which had not been previously worked for uranium. The bonus was collected once, prior to the expiration of the Circular on April 11, 1958.

Circular 3 (April 11, 1948) provided for minimum prices, specifications, and conditions under which the AEC would purchase carnotite and roscoelite-type ores at Monticello, Utah. It also established payment of 31 cents a pound for the vanadium content (V_2O_5) of the ores.

Circular 4 (June 1, 1948) provided for payment of haulage and development allowances for uranium ore producers.

*Announcement dated November 17, 1962, and published in the Federal Register, November 20, 1962, 27FR11435.

Circular 5 (February 1, 1949) consolidated Circulars 3 and 4, increased the price of U_3O_8 in ore, and established premium prices for higher grade ore. This Circular was revised and broadened March 1, 1951, and remained in effect as Circular 5, Revised, through March 31, 1962.

Circular 6 (June 29, 1951) offered bonus payments for initial and certain other production of uranium ores to assist in development of new sources. The Circular expired March 31, 1960.

A necessary corollary to price guarantees set forth in the Circulars was the provision of Government ore-buying stations in areas of expected production. The first of these was set up at Monticello, Utah, where the AEC was reconstructing for uranium production a vanadium processing plant acquired from the War Assets Administration. Ores were purchased at Monticello from 1948 through March 31, 1962, with the expiration of Circular 5, Revised.

During the next several years, the AEC established ore-buying stations in the new uranium-producing areas where it appeared ore production would be sufficient to support a mill. If and when a mill was built to provide the necessary market for the ore, the AEC would withdraw and the stockpiles of ore accumulated by the AEC would be sold later to the mill for processing.

AEC ore-buying stations were established and operated for varying periods at the following places: Marysvale, White Canyon, and Monticello, Utah; Shiprock and Grants, New Mexico; Globe and Tuba City, Arizona; Riverton and Crooks Gap, Wyoming; and Edgemont, South Dakota. In addition, the AEC made arrangements for mill contractors and the AEC ore-buying agent to purchase uranium ore at Bluewater and the Ambrosia Lake area in New Mexico; Salt Lake City and Mexican Hat, Utah; the Shirley Basin area in Wyoming; and in Karnes County, Texas. These arrangements were for limited periods of time, and usually while mills were under construction.

By their terms, Circular 5 and Circular 5, Revised, provided for uranium prices, specifications, and conditions under which the AEC would purchase carnotite and roscoelite-type ores at its Monticello, Utah, ore-buying station. In practice, however, the AEC was guided by the terms of the circulars in its payment for ores at the other buying stations, although it sometimes deviated from those terms; for example, by making deductions for high lime content in the ores, by adding a price factor for ores containing copper, or by deleting the payment factor for vanadium.

The AEC also required, during the period prior to April 1, 1962, that uranium companies selling concentrates to the AEC must pay for the uranium content (and in appropriate cases, the vanadium content) of purchased ores at prices, premium, and allowances not less favorable to the ore producer than the provisions of Circular 5 (later Circular 5, Revised).

ANCILLARY PROGRAMS

From 1948 until the mid- and late-1950s, the AEC pursued several programs designed to increase quantities of uranium available for Government procurement. While these were not uranium procurement programs as such, brief mention is made because of their considerable impact on the AEC purchase programs and, ultimately, its procurement policies.

Between 1948 and 1956, the AEC, assisted by the U.S. Geological Survey, pursued a broad program of uranium exploration. Several hundred AEC and USGS geologists searched for uranium deposits, first in the Colorado Plateau area and ultimately in Wyoming, New Mexico, and parts of several other western states. The program involved temporary withdrawal of some 700 square miles of public domain for exploration, geologic studies, drilling and examination of samples, and airborne reconnaissance. Results were regularly published for use by private companies and individuals. Where no ores were found, the lands were promptly returned to the public domain.

When ores were discovered by AEC drilling on withdrawn lands, the AEC leased the lands to private parties in return for a royalty on ore production. A total of 49 leases were issued between 1949 and March 31, 1962, when this leasing program was terminated.

Another aid to private industry exploration and production was an access-road program under which the AEC, in conjunction with the Bureau of Public Roads and various state agencies, improved over 1200 miles of roads in Arizona, Colorado, New Mexico, South Dakota, Utah, and Wyoming. These improvements, accomplished between 1951 and mid-1958, provided access to uranium mining areas and mill facilities.

The AEC also conducted research and development leading to improvements in milling processes, and shared the results of its studies with the private sector.

URANIUM CONCENTRATE PROCUREMENT

As noted earlier, the main objective of the AEC raw materials program was the acquisition of uranium concentrate coupled, particularly in the later stages of the program, with the objective of maintaining a domestic uranium-producing industry capable of supplying raw materials required for peaceful uses of atomic energy, primarily nuclear power production.

Beginning with the first concentrate procurement contract in May 1947, the number of privately owned and operated uranium processing mills under contracts with the AEC grew until, in 1961, there were 27 mills operating.

Contracts were negotiated pursuant to the Atomic Energy Acts of 1946 and 1954, which authorized the AEC to establish guaranteed prices for source materials delivered to it within a specified time. The contracts were initially entered into for periods of 5 years or more so the milling company would have an opportunity to amortize plant costs during the contract term.

Prior to negotiating a contract with a milling company, the AEC required submission of a detailed proposal showing that the company could meet the AEC requirements for an adequate ore supply, technical capability, and financial responsibility. If these requirements were met, the AEC and the company negotiated a contract for the construction and operation of a processing plant of a specified nominal capacity in terms of tons of ore per day processed. The price per pound of U_3O_8 in concentrate was arrived at through negotiation, with the AEC taking into account ore cost, estimated milling cost (including plant amortization), metallurgical losses, and profit. Ore cost was calculated by using ore prices set forth in Circular 5 (later Circular 5, Revised) both with respect to ores to be purchased by the milling company and ores which it owned or controlled.

Initially, and in all cases prior to May 8, 1958, the contracts required that the entire production of the processing plant be delivered to the AEC, limited to the annual maximum quantities which it was obligated to purchase under the contract. The contracts also generally required the milling company to purchase ores from independent ore producers, if offered, within a stated percentage of the mill's ore requirements. In some cases, the contracts provided an increase in AEC concentrate purchase obligations to include production from independently produced ores which the AEC might direct to the mill. In a few cases, the AEC agreed to purchase vanadium concentrates which were produced in conjunction with the uranium and for which there was an inadequate commercial market. In other cases, it reimbursed milling companies at Circular 5, Revised, prices for vanadium contained in the ores, and directed the companies to allow the vanadium to go into the tailings piles rather than recovering it.

This general pattern of negotiation and contracting practice prevailed with respect to uranium concentrates purchased by the AEC through March 31, 1962. By that date, a total of 28 processing mills had been constructed and 23 were in operation in the western United States.

As of the mid-1950s, the AEC Domestic Uranium Procurement Program had not been defined for any period beyond March 31, 1962. Its announcement issued May 24, 1956, provided that definition by establishing a new domestic procurement program for the period from April 1, 1962, through December 31, 1966. The action was taken "in recognition of the need for a continuing Government market in order to maintain a high rate of exploration and development." The announcement noted that assurance of such a market would assist uranium mining and milling firms in planning future operations, and expressed the AEC expectation that a gradual transition from a Government-controlled market to a commercial market would take place as industrial demand developed.

The new program established a flat price of $8 per pound for U_3O_8 in concentrate purchased by the AEC subsequent to March 31, 1962, and guaranteed a Government market for all uranium concentrates produced by domestic mills from domestic ores, subject to a limitation of 500 tons of U_3O_8 per year from any one mining property or mining operation. The AEC ore purchase and price guarantees would be discontinued after March 31, 1962.

In contracts and contract modifications and extensions executed after May 24, 1956, the concentrate price structure and the contractors' obligations regarding payment for independent ores were defined separately for the period of the contract ending March 31, 1962, and for the period beginning April 1, 1962, and ending December 31, 1966. Through March 31, 1962, the concentrate price continued to be a negotiated one; as of April 1, 1962, it became the announced $8 per pound, with a few exceptions where an amortization factor was added to the $8 price to take care of plant amortization which had been negotiated but could not be recovered by March 31, 1962. Conversely, through March 31, 1962, the mill contractor was required to pay at least Circular 5, Revised, prices, premiums, and allowances for purchased ores; after March 31, 1962, the requirement was that the mill operator pay "reasonable" prices.

Soon after the 1956 announcement, large ore discoveries were made in Wyoming, and the potential of the Grants, New Mexico, area was becoming apparent. These developments prompted the AEC to announce on October 28, 1957, that "it is no longer in the interest of the Government to expand the production of uranium concentrate." The objective of the AEC would be to limit production to the approximate level which would be reached as a result of existing commitments.

If new contracts were to be considered, preference would be given to providing a limited market for areas having inadequate milling facilities. This "limited expansion" was implemented through execution of new contracts and the amendment and extension of existing contracts to allow for treatment of increased amounts of ore from southeast Texas, the Gas Hills and Crooks Gap areas of Wyoming, the Colorado Front Range, and the Moab and Mexican Hat areas of Utah.

By its announcement of November 24, 1958, the AEC withdrew prospectively its April 1, 1962, through December 31, 1966, uranium concentrate procurement program which had been announced on May 24, 1956. In effect, it would carry out its May 24, 1956, commitment but only with respect to ore reserves developed prior to November 24, 1958, in reliance upon the earlier announcement. It would do this by negotiating for the purchase of appropriate quantities of concentrates derived from such ore reserves during the period from April 1, 1962, to December 31, 1966.

In the months following the November 24, 1958, announcement, a determination of eligible properties was made and an allocation system was established by the AEC. Under this system, an eligible mining property was identified as a property having a market quota (allocation) established by the AEC under the terms of the announcement. Allocations were based on ore reserves developed prior to November 24, 1958, (or in certain areas having irregular uranium deposits which were normally not developed prior to mining) on the property's production history during the period July 1, 1956, through June 30, 1960.

The AEC received requests for allocations for more than 2500 uranium properties, but investigations of many of these showed no developed reserves, and the AEC ultimately issued a total of 800 allocations. In some cases, owners applied for allocations on properties from which it was unlikely that uranium could be mined at a profit. The AEC chose not to substitute its judgment for that of the property owner, however, and allocations were issued for properties on which reserves had been developed before November 24, 1958, even though economic production might be doubtful.

Along with the determination of allocations under the November 24, 1958, announcement, a review was made of the situation of the small independent mining properties which indicated that many of them could not sustain an economic operation at the production levels imposed by the allocations. To assist this group of some 600 small properties, in June 1962, the AEC issued an announcement which permitted mills to purchase, under AEC-approved contracts between the mill and mine operator, up to 20,000 pounds U_3O_8 in ore annually from eligible small properties, subject to an overall group limitation of 1 million pounds per year.

A few contracts were to terminate earlier than 1966 for various reasons, but most procurement contracts were rewritten in accordance with the November 24, 1958, announcement and extended through 1966.

Again, for the remainder of the pre-April 1, 1962, period, the contracts retained their former characteristics with respect to negotiated concentrate prices and requirements for purchasing ores under the provisions of Circular 5, Revised. In the period beginning April 1, 1962, the AEC would pay $8 per pound for the U_3O_8 in concentrate, and the milling company would pay "reasonable" prices for ores acquired from independent producers.

By this time, the ban on private sales of uranium concentrates had been lifted, so the contract modifications generally provided that the milling companies could sell concentrates to other than the AEC. In the pre-April 1, 1962, period, prior, written, AEC authorization was required for such sales. Thereafter, any concentrate production in excess of the AEC purchase obligation could be sold to any properly licensed buyer without AEC approval.

The most substantive change in the contracts was caused by the fact that they became the vehicles by which the AEC enforced its allocation program in the period beginning April 1, 1962, so as to purchase no more than the appropriate quantity of concentrate ascribable to each mining property's allocation. To accomplish this, it was necessary for the milling contract to describe each separate mining property controlled by the milling company and to specify the number of pounds U_3O_8 which would be purchased as to each such property. An agreed-upon mill recovery factor was applied to translate the property's allocation of U_3O_8 in ore to an appropriate quantity of U_3O_8 in concentrate. Further, provision was made for AEC approval of each ore purchase agreement entered into by each milling contractor. The ore purchase agreement was required to specifically describe the property or properties from which the ore would be produced, and the maximum quantity to be purchased from each such property. The maximum purchase obligation of the AEC, in each concentrate procurement contract, was a combination of pounds U_3O_8 allocated the properties owned or controlled by the milling company, plus pounds U_3O_8 allocated to mining properties from which the mill company acquired ores under AEC-approved agreements. Since substitutions of ore from one property to another were not allowed, any shortfall in ore production below a mining property's allocation resulted in a commensurate reduction of the AEC maximum purchase obligation.

The last major change in the AEC procurement policy was announced November 17, 1962. The announcement established a new program for the period January 1, 1967, through December 31, 1970, noting that AEC requirements for U_3O_8 through 1970, as then currently estimated, were significantly below the amounts which would be available if domestic operations continued through that period at current levels. So, to effect a better balance between AEC receipts and requirements and to help provide for a continuing industry to supply the anticipated commercial market, the AEC offered the mill operators the option of deferring a portion of the U_3O_8 contracted for delivery to AEC in 1963-1966, and delivering it in 1967 and 1968. In return, in 1969 and 1970, the AEC would purchase an additional quantity of U_3O_8 equal to the amount deferred. The price to be paid for the deferred material in 1967 and 1968 would be $8 per pound, the same as in the 1962-1966 contracts. The price to be paid in 1969 and 1970 for concentrates produced from properties controlled by the mill contractor would be based on a cost formula for the 1963-1968 period, subject to a maximum price of $6.70 per pound of U_3O_8. The price for all concentrates produced from ores purchased from independent producers would be $6.70 per pound of contained U_3O_8.

Uranium milling companies were invited to submit proposals covering the quantity of material they would be willing to defer for delivery after 1966. For the next 3 years, the AEC engaged in lengthy negotiations with the various companies to work out details for the so-called "stretch-out." Several firms elected not to participate in the program, but 11 companies did so. They were: Vanadium Corporation of America, mill at Shiprock, New Mexico; The Anaconda Company, mill at Bluewater, New Mexico; Western Nuclear, Inc., mill in Fremont County, Wyoming; Utah Construction and Mining Company, mill in Fremont County, Wyoming; Kerr-McGee Corporation, mill near Grants, New Mexico; Atlas Corporation, mill at Moab, Utah; Federal-Radorock-Gas Hills Partners, mill in Fremont County, Wyoming; Homestake-Sapin Partners, mill near Grants, New Mexico; United Nuclear Corporation, mill near Grants, New Mexico; and Union Carbide Corporation with two contracts, one for U_3O_8 production from the mill in Natrona County, Wyoming, and the other for production from the two mills at Uravan and at Rifle, Colorado.

Negotiation of the stretch-out contracts began in 1963, and final contract modifications (actually, complete rewritings of the contracts) were signed November 26, 1965. During the negotiation and preparation of the formal contracts, the contractors reduced their operations beginning as early as 1963, under letter agreements with the AEC which would enable the milling companies to make up for any reduced deliveries of concentrates should negotiations fail. Consequently, total AEC purchase of U_3O_8 in concentrate began to decline as early as June 1963.

Under the stretch-out contracts, the allocation system was continued in effect through 1968, but thereafter the milling companies were free to produce concentrates from any domestic ore source without regard to allocations. Throughout the period January 1, 1963, through December 31, 1970, the milling companies were free to produce uranium concentrate in excess of that which the AEC was obligated to purchase, and to sell such excess concentrate to any purchaser properly licensed to receive it. The only prohibition was that such sales could not be made to a purchaser acquiring such concentrate for resale to the AEC.

The AEC uranium procurement program ceased with the expiration of the stretch-out contracts on December 31, 1970.

APPENDIX E: MILL OWNERS' COMMENTS

Five companies provided written comments on drafts of this technical report. General comments relating to the companies' positions on key issues have been extracted from the companies' original transmittals and are listed below.

COTTER CORPORATION

The draft report failed to adequately address costs incurred during the operation of the mill prior to shutdown. Cotter and other companies have already expended considerable sums for reclamation, stabilization, and monitoring purposes, a portion of which are directly attributable to AEC-contract tailings. Cotter will incur more of such costs in the future prior to shutdown. The cost factor section of the report should be expanded to specifically discuss and identify these costs and recommend including them as part of the costs to be shared. Cotter has identified many of these interim costs in the Cotter site report.

The section of the draft report dealing with short-term cost factors underestimates the amount of many of these costs. Furthermore, there are no costs indicated for machinery and equipment removal despite the likelihood that there will be significant costs associated with the removal of these items.

Cotter requests that DOE specifically identify and recommend the following items as costs to be shared:

a. Costs associated with the transfer of commingled tailings to new impoundments, prior to and following shutdown, including costs associated with the transfer of contaminated soil and reclamation of the old tailings sites;

b. Costs of ground-water and surface-water studies, monitoring, protection measures, and cleanup;

c. Costs of design, engineering, site preparation, and construction for new impoundments to which commingled tailings are transferred; and

d. Costs reflecting the time value of money already spent by mill owners for costs attributable to commingled tailings.

As previously indicated, Cotter's recommendation with respect to the cost-sharing formula to be used is basically a tonnage approach, with flexibility for modification where site-specific circumstances warrant a different approach. A flexible tonnage method appears to be the most practicable approach and should in most instances yield an equitable result.

With regard to the timing of payments from the Federal Government for shared costs, Cotter recommends that such payments occur as costs are incurred. For those costs incurred by mill owners prior to passage of legislation and implementation of the cost-sharing program, Cotter urges that reimbursement occur as soon as the regulatory and administrative regime is set up, and, as previously mentioned, that these reimbursements reflect the time value of money.

DAWN MINING COMPANY

Dawn acknowledges that if DOE interprets its tonnage ratio cost-sharing approach as applicable on an individual basis to each tailings pile within a facility, then the Government's obligation for stabilization funding appears to be much the same as in Dawn's recommended approach, which is to make AEC-related tailings piles a 100 percent Government responsibility and commercial production tailings piles a 100 percent corporate responsibility. There are two important differences, however: (1) DOE includes within its tonnage ratio approach several other variants of the concept which, although possibly appropriate for some mills, are manifestly inequitable for Dawn, because costs are largely a function of area to be stabilized, not tonnage; and (2) by stating that each party's obligation to carry out remedial action is independent of actions by the other, Dawn's approach assures an operator of the management flexibility necessary for cost-effective performance. More specifically, it would allow for differences in the timing of remedial actions, and in choice and management of contractors.

It is also recognized that the second DOE approach, cost-share on the ratio of area covered with AEC-tailings to total tailings area, appears to be similar in effect to Dawn's recommendation, provided DOE chooses, as the embodiment of its area concept, the version in which Government share is taken as "the total area covered by tailings impoundments at the end of the Government contract." Once again, however, there are two important differences: (1) Dawn's approach avoids the philosophical problem raised by DOE of possible overcompensation by the Government, where commercial production tailings have been placed on top of AEC-related tailings; and (2) Dawn explicitly provides for independence of action by each party, desirable for the reasons given above.

To remove these needless ambiguities and provide clear, equitable resolution, Dawn urges DOE to add a sixth alternative to its lists which might read:

6. Assign to the Government 100 percent responsibility for stabilization of those piles which contain only AEC-related tailings, and assign to the operator 100 percent responsibility for piles which contain only commercial production tailings.

Dawn's cost-sharing approach detailed above is intended to apply essentially to stabilization; the company recognizes that many of the smaller cost components (e.g., monitoring, mill decommissioning, maintenance) do not fit the separate area approach, even for Dawn. The company has suggested that some production-related basis would be more appropriate for such costs, and stated its preference for the formula:

$$\text{Government Share} = \frac{\text{Lbs. } U_3O_8 \text{ Produced for AEC Contract}}{\text{Total Lbs. } U_3O_8 \text{ Produced}}$$

In order to allow matching of formula to type of cost, Dawn suggests that text be added to the section on cost-sharing approaches, specifically analyzing the list of cost items and linking each to the formula (or formulas) with which it is compatible. Dawn would not expect this exercise to be demanding or lengthy.

KERR-MCGEE

The discussion of costs in the draft report is confusing and, in some respects, misleading. It is not clear why such extensive discussion is warranted, particularly when the draft report notes that "good cost data for actual performance of remedial action under UMTRCA are yet to be generated." Kerr-McGee believes that EPA and NRC unit cost estimates, on which the draft report relies, are unrealistic and outdated. They are also misleading. For example, the NRC estimate for moving tailings for disposal below grade appears to be based on the cost for newly generated tails and not for retrofitting a system to tails already generated.

Kerr-McGee is also disturbed by the draft report's use of company-supplied cost estimates. These estimates are based on widely varying assumptions and, in some cases, on different regulatory requirements. Kerr-McGee also believes that the cost estimate for annual surveillance ($160,000) is much too high. The NRC estimate is $2500 per year per site, and this estimate allows for many days of "processing time" in the office. Even NRC's estimate is unduly high.

The material concerning the alleged benefits of stabilization is useful and should be expanded. The report should take into account DOE's position which is already partially articulated in the DOE comments on the EPA inactive site standards [Letter, Mr. Greenleigh (DOE) to Ms. Selander (EPA), July 15, 1981], and more extensively in Dr. Burr's testimony on behalf of DOE before the Armed Services Committee.

The draft report raises several policy issues which merit specific comment. First, the draft report hints that a 1968 cutoff date may be appropriate for purposes of Government sharing of costs. This is insupportable. All sales, including those in 1969-70, to the AEC should be covered by the DOE plan, as indicated in Section 213 and the Comptroller General's report.

Second, the draft report hints at the possibility of DOE assuming control of the piles in which commingled tails are located for purposes of performing the remedial action. Under this scenario, DOE would evidently bill private companies for their share of the costs incurred by DOE contractors in stabilizing the site. Kerr-McGee does not support this approach. It subjects the company to liability for remedial action by contractors and institutions which it does not control. Kerr-McGee cannot support loss of control over its costs. The company believes that the Government should pay its share of the costs as they are incurred.

Kerr-McGee believes that, although tailings were used for backfill, there is a future possibility that regulatory problems could address the possible contamination of ground water from these tailings, and current land ownership requirements could require ownership of property where tailings are deposited. Kerr-McGee points out that these tailings used for backfill would be considered AEC tailings in the same proportions as in the main pile at the end of the AEC contract period.

Kerr-McGee feels there are no more variances with respect to acreage determinations than variances involved in tonnage determinations. Data on the area extent are as complete as is needed at this time, and the company considers aerial photographs to be "representative" information.

TENNESSEE VALLEY AUTHORITY

TVA continues to object to any adjustment being made for the quantity of tailings which might have had co- or by-products extracted: The arguments presented are of sufficient importance to negate the removal of co- or by-products from calculations. The fact remains that the ore was originally processed for the extraction of uranium primarily for defense purposes. Any adjustment for products other than uranium is clearly unwarranted.

TVA recognizes that a good comparative estimate of costs for the various mills is difficult to make, particularly in the light of what may well be thirteen sets of assumptions. TVA would also like to point out that the cost of ultimate disposal of tailings is not the final cost. One must keep in mind the costs associated with decontamination/dismantling of equipment and buildings, removal of contaminated subsoil, and health and safety programs. These costs will be no small amount.

TVA has a continuing concern over retroactive funding. The report illustrates the potential magnitude of interim stabilization costs already incurred. Many of the mills will have these types of costs before final reclamation and decommissioning of currently active mills. Without recognizing these interim stabilization costs, the final costs will be even higher than currently estimated.

TVA believes all cost estimates should be revised to reflect 1982 dollars and to provide a more updated cost summary. In general, the costs in the Nuclear Regulatory Commission's GEIS are believed to be low. One must remember that the GEIS estimates are for a new mill. Many of the lower estimates in the GEIS result from portions of the stabilization costs being considered as operating costs for mining and milling (e.g., pit preparation costs can be partially written off as mining costs).

WESTERN NUCLEAR, INC.

WNI does not believe the costs generated by the NRC, EPA, or consulting firms are realistic. It is extremely difficult, if not impossible, to establish costs without a site-specific evaluation based upon applicable state and Federal Government regulations.

The costs Western Nuclear is presently incurring to comply with existing federal and state regulation have not been addressed.

WNI discussed with DOE the appropriate AEC contract cutoff date. The DOE cutoff date for WNI is June 30, 1969. WNI's position is that the cutoff date should be June 30, 1970. The 1968 cutoff date is not applicable to WNI.

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